Electrical Engineering

October
1938

Published Monthly by the
American Institute of Electrical Engineers

Electrical Engineering

Registered U. S. Patent Office

for October 1938—

VOLUME 57 NUMBER 10

Published Monthly by the

American Institute of Electrical Engineers

(Founded 1884)

Entered as second class matter at the Post Office, Easton, Pa., April 20, 1932, under the Act of Congress March 3, 1879. Accepted for mailing at special postage rates provided for in Section 1103, Act of October 3, 1917, authorized on August 3, 1918. ¶ Publication Office: 20th & Northampton Streets, Easton, Pa. Editorial and Advertising Offices at the headquarters of the Institute, 33 West 39th Street, New York

The Cover

On the 132-kv system of the Ohio Power Company near Shelby

Ohio Brass Company Photo

High Lights

New Telephone Instruments. Two papers in this issue describe new telephone instruments, which were introduced into service on the Bell System in 1937. One paper (*Transactions pages 559–64*) describes the instruments themselves, their design, and some of the structural characteristics; the other outlines transmission characteristics of telephone instruments in general, and shows how performance has been improved in the new instrument (*Transactions pages 606–12*).

Speed Control. Combination of thyratron control of motors with a tachometer whose output is used to control the motor input makes possible a small motor whose speed may be held constant under difficult conditions or varied rapidly in exact accordance with requirements. Applications are found in null-type high-speed recorders, high-speed controllers, and a motor-generator set synchronized with a constant-frequency low-power source (*Transactions pages 565–8*).

Oil-Impregnated Paper. Results of life-test studies on miniature cable specimens may contribute much to existing knowledge of power-cable failures. A paper in this issue, third in a series, attempts to show that with either paper of high density or an impregnant of high viscosity the flow of impregnant through the paper during the cooling portion of the daily heat cycle is not great enough to prevent void formation, consequent ionization and breakdown (*Transactions pages 573–9*).

Phase Shifting. To control the direction of power flow in an interconnected system loop, which may be used in emergencies, a large phase-shifting transformer is used that, by a series-parallel arrangement, may feed as much as 20,000 kw in one direction, or 40,000 kw in the other by control of the shift of phase angle. Net phase-angle shifts for the two conditions are 28 degrees and 15 degrees, respectively (*Transactions pages 579–87*).

Weather Forecasting. Modern, scientific forecasting of weather depends on rapid electrical communication to enable short-range forecasts such as are required for airways; new studies indicate the possibility of forecasts being extended to nearly a week. Recently radio has been used to transmit data from "robot observers" in stratosphere balloons and on mountain summits (*pages 405–12*).

1937 Lamme Medalist. Robert E. Doherty, 1937 AIEE Lamme Medalist, is a man of broad, diversified interests—yet a man with but a single purpose. He ranks high as an engineer, as a teacher, and as an executive. The story of this interesting man is told by a former colleague (*pages 420–3*).

AIEE Southern District Meeting. Plans for the AIEE Southern District meeting, November 28–30, 1938, provide for a generous amount of recreation and relaxation in picturesque Miami, Fla., as well as carefully planned technical sessions (*page 425*).

Field Tests of Bushings. Maintenance of insulation in good condition on all parts of a power system is essential to dependable operation. Of particular importance are bushings and transformers, which are satisfactorily tested by means of a field test of power factor. The application of this method on an expansive electric system is described in this issue (*Transactions pages 589–96*).

IEC Committees Meet. Torquay, England, was the scene of the ninth plenary meeting of the International Electrotechnical Commission, June 22–July 1, 1938. A new IEC committee on welding was formed, an international dictionary of electrical terms was approved for publication, and most of the committees submitted reports or final agreements (*page 424*).

Telephone Routes. Recent new construction has increased to four the number of transcontinental telephone routes. Some structural details have been modified in the new lines in order to take advantage of recently developed carrier systems operating at frequencies higher than formerly used (*pages 418–19*).

Supervisory Control. Selection time in large multistation supervisory-control systems may be reduced by eliminating the checking operation. A self-checking system has been developed that is based on the use of short or long electrical pulses, and is applicable to telephone lines or carrier-current channels (*Transactions pages 600–5*).

Lightning Protection. A decrease of 86 per cent in the index representing station-equipment faults in per cent of total system faults has been shown in the operating records of one power company following co-ordination of insulation and lightning-arrester performance in 22-kv substations (*Transactions pages 568–72*).

NRC Subcommittee Meets. Milwaukee, Wis., was the scene of the third successive joint meeting of the subcommittee on chemistry of the committee on insulation of the National Research Council and the American Chemical Society (*pages 426–7*).

1939 World's Fairs. Electricity will play a practically indispensable role in the World's Fairs to be staged next year in New York, N. Y., and San Francisco, Calif. Monuments to engineering achievement, the expositions will hold much of interest to electrical engineers (*pages 428–29*).

Labor Policy and Employment. Unemployment during the recovery period 1933–37 was primarily in industries that had not made sufficient technological advance, in the opinion of one economist (*pages 413–17*).

Coming Soon. Among special articles and technical papers now undergoing preparation for early publication are: an article discussing the objectives of industry in training engineering graduates, by L. W. W. Morrow (F'25); a paper on the design of harmonic generators, by F. E. Terman (M'34); two papers on air circuit breakers—one describing breakers for a-c feeder, motor starting, and station auxiliary service, by R. C. Dickinson (A'37) and the other describing low-voltage apparatus of high interrupting capacity, by Jerome Sandin (A'38); a paper describing an electronic position regulator for paper slitters, by F. H. Gulliksen(M'35); a paper on a static constant-current circuit, by C. M. Summers (A'30); a paper discussing some of the radio influence characteristics of electrical apparatus, by P. L. Bellaschi (A'34) and C. V. Aggers; a report of the lightning arrester subcommittee of the AIEE committee on protective devices, presenting performance data on lightning arresters of the line type; a paper describing a "memory attachment" for oscilloscopes, by W. E. Pakala (A'38); a paper on the electric strain gauge, by M. A. Rusher (A'12) and A. V. Mershon; and a paper on noise co-ordination of rural power and telephone systems, by H. W. Wahlquist (M'36) and T. A. Taylor (M'36).

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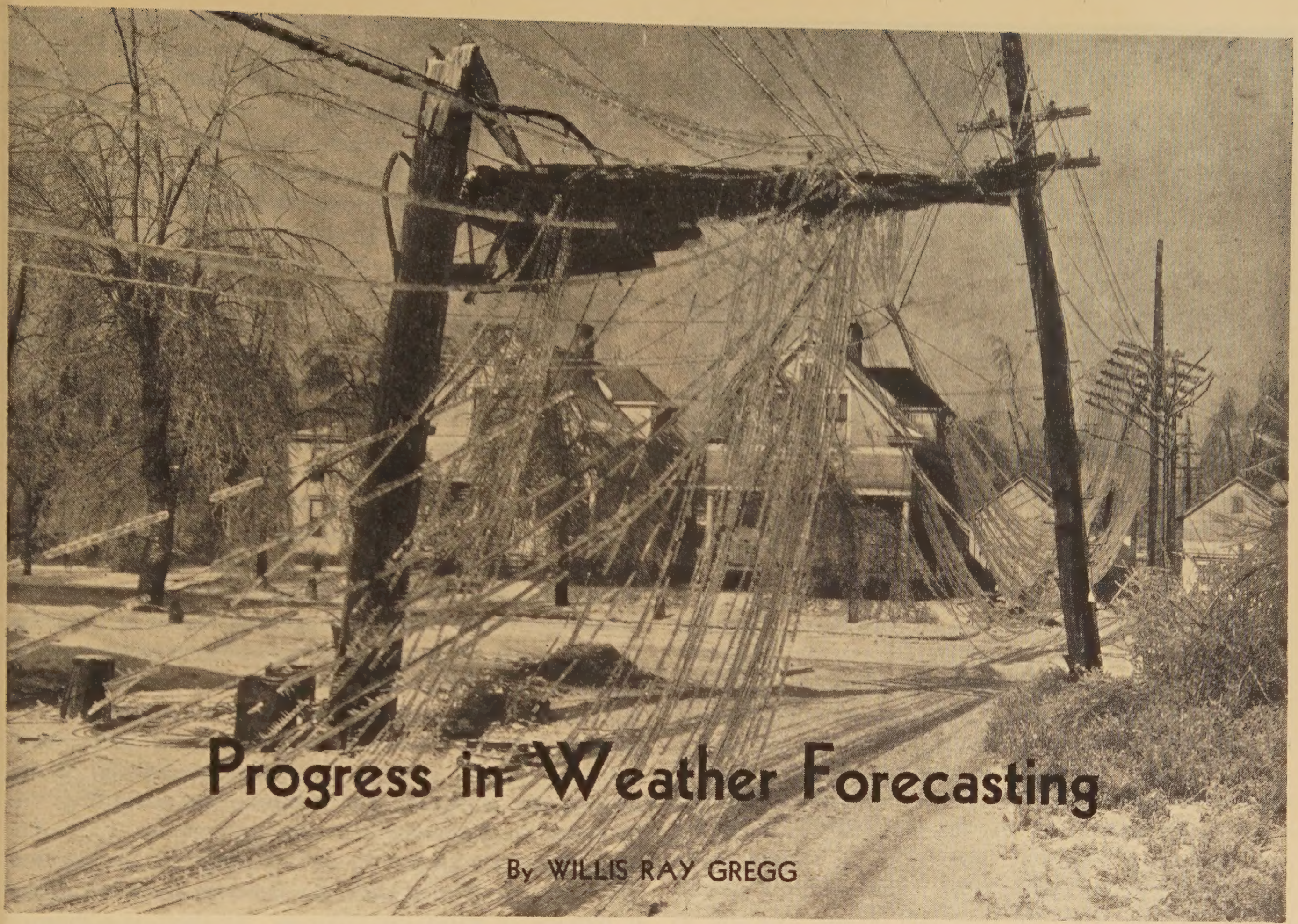
Number of copies this issue—20,400.



Progress in Weather Forecasting

By WILLIS RAY GREGG

Electricity and weather conditions are associated in two ways: electrical apparatus and structures are subject to damage by storms; and communication by telegraph, telephone, teletype, and radio is essential for weather forecasting. How the United States Weather Bureau has made increasing use of the information gathered from many stations for scientific forecasting, particularly for special services such as that for airways, is described in this article.

MAJOR storms and disasters, such as floods and hurricanes, may affect in a vital way electrical services, both power and communication. Before taking up the general subject of forecasting, however, it is proper to point out that, without the aid and achievements of the electrical engineer, meteorological service as it is known today would be utterly impossible. Dependence would still be placed on the astrologer, on the goosebone, rheumatic joints, saints' days, the ground hog, almanacs of various kinds, and so forth. It is interesting to recall that organized meteorological observations were not unknown to antiquity; in fact, Aristotle received reports from several hundred stations and wrote the first known treatise on the subject, but the reports were received by messenger; therefore, too late for current use.

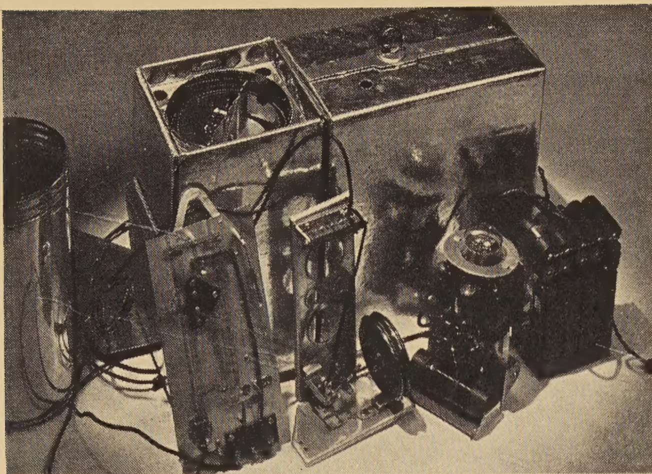
Communication by Telegraph, Telephone, and Teletype

Down through the centuries other attempts were made to do something about the weather, not merely to talk about it, but it was only when electric communication was provided that anything really worth-while could be done about it. Significantly, within five years of the date, 1844, when the telegraph first came into public use, it was employed by the Smithsonian Institution in collecting weather reports for the purpose of forecasting storms. Its utility and value in this connection were quickly sensed by other countries. In November, 1854, a violent storm wrought havoc among the French and British warships in the Black Sea and sank many vessels containing invaluable stores intended for the allied armies in the Crimea. The French astronomer, Le Verrier, director of the observatory of Paris, collected information showing the progress of this storm across Europe, and the results of this inquiry were so significant that he sub-

Essentially full text of an address delivered at the AIEE summer convention, Washington, D. C., June 20–24, 1938.

Willis Ray Gregg was chief of the United States Weather Bureau, Washington, D. C., from 1934 until his death September 14, 1938. A graduate of Cornell University in the class of 1903, he was with the Weather Bureau continuously from 1904, and since 1926 had been engaged in organizing weather service for commercial airways activities. He was chairman of the executive committee of the National Advisory Committee for Aeronautics, and a member of several technical societies.

The author was indebted to Doctor Horace R. Byers of the Weather Bureau for helpful suggestions in the preparation of the sections on "Physical Basis of Forecasting" and "Research."



Diamond-type radiometeorograph, showing mechanism for recording pressure, temperature, and humidity

mitted to the Emperor Napoleon III the plan of organizing an international system of telegraphic reports, by means of which timely warning could be obtained of similar atmospheric disturbances. The French government, with the aid of other European countries, established such a system in 1855. Within the next two decades most of these countries organized their own services, and at the same time maintained an international exchange of observations by telegraph. Service in the United States was officially authorized in 1870. Thus within a generation of the time when the telegraph became available as a means of communication, practically all civilized nations were making use of it in providing daily forecasts and warnings for their people.

Later came the telephone which supplemented the telegraph in a most effective way, both in the collection of reports and particularly in the dissemination of meteorological information, including forecasts and warnings, to millions of people requiring such service. The fact that more than 8,000 telephone calls were received and answered at the Weather Bureau office of one large city, in the short space of 24 hours, during a flood emergency, indicates the tremendous importance of this means of communication in performing the functions of a meteorological service.

Then there is the teletype which provides an almost instantaneous exchange of reports at frequent intervals along more than 21,000 miles of airways and, during the hurricane season, connects many reporting stations along the Gulf of Mexico and south Atlantic coasts. It is destined to be still further extended, eventually combining into one system the entire network of meteorological stations in this country and probably in others.

Radio Communication

It is not too much to say that the introduction and widespread use of radio marked the beginning of an epoch comparable only to that initiated by the telegraph. It has extended the meteorological horizon to the seas and to remote and isolated regions of the continents. The first weather report from a ship in the Atlantic was received December 3, 1905; in the Pacific, June 18, 1907; and in the Caribbean, August 26, 1909. In 1906 the total number of marine reports received was 738; in 1922, 1,500; in 1933, 56,800; and in 1937, 89,165.

The record as regards land reports is no less noteworthy. International exchanges were begun in 1921, and at the present time twice-daily bulletins are received from Rugby and Cavite as well as individual reports from many other points, including several stations in northern Siberia, northern Canada, and Greenland. The isles of the Pacific and of the Caribbean add their quota to this ever increasing volume of data, with the result that twice-daily weather maps of the entire Northern Hemisphere now are made and the time is not far distant when such maps for the whole world will be available.

So much for radio as a collector of reports; its role as a disseminator is equally impressive. Naval radio broadcasts were begun in 1904. All marine interests now receive forecasts and warnings in this way. Radiophone broadcasts in the United States were begun in 1921, the first one being by the University of Wisconsin on January 3, 1921. The first flood warnings were broadcast by the University of Missouri on April 26 of the same year. At present there are 435 radiophone stations regularly broadcasting forecasts and warnings for the benefit of the farmer, the merchant, the shipper, the orchardist, the housekeeper, the baseball fan, the motorist, and the golfer. Radio not only guides the aircraft pilot on his way but keeps him constantly informed of current weather ahead of him and of impending changes. In short, it is difficult to visualize a meteorological service without radio as a chief factor. Yet, with all that it is and does, undoubtedly only a beginning in taking advantage of its possibilities has been made. Already complete weather maps are being transmitted to ships at sea. This service is in the experimental stage at present, but will certainly be extended and will include ships in the air and distant land stations also. But the most far reaching development, now rapidly passing out of the experimental phase, is that wherein radio plays the role of a meteorological observer as well as that of a transmitter of the data. This refers to the apparatus that is variously known as the radiosonde, radio telemeter, or, generally up to the present time in the United States, as the radiometeorograph.

Significance of the Radiometeorograph in Meteorological Service

Space does not permit more than a brief statement regarding the design of this instrument. It consists essentially of a radio transmitter which is actuated by a barometer, a thermometer, and a hygrometer, all of extremely light weight but high precision. Four principles of operation have been employed. The most widely used is the Olland system of telemetering (a simple form of television) in which an attempt is made to telemeter the position of the index of the meteorological element relative to a time scale. The next in order of general use is one in which the meteorological elements vary the capacities

of the radio-frequency oscillator, thereby varying the carrier frequency. Another principle of operation is to key the carrier by means of the meteorological elements, thus causing a sequence of coded signals to be transmitted. Finally, there has been employed an audio oscillator whereby the carrier frequency is modulated and produces variations in modulation by changes in resistances that are varied by the meteorological elements.

Each of these designs has certain advantages and disadvantages. It is too early as yet to say definitely which one ultimately will prove to be the most efficient, but all have been brought to a point already where they give reasonably reliable data. During the present fiscal year different designs have been used by the Weather Bureau at three places and the present plan is to extend the program to include six stations. The experience of this coming year and the improvements resulting from that experience will, it is believed, make possible the adoption of one design, or possibly a combination of the best features of two or more, as the most efficient, and to substitute this method of upper air exploration for others heretofore employed, so far as pressure, temperature, and humidity are concerned. There remains the problem of adapting this apparatus to include measurements of air movement. This is difficult but it is being attacked and there is good reason to expect that it will be solved.

The regular use of the radiometeorograph will unquestionably mark the beginning of a new epoch in meteorological service. Attached to a balloon, it will ascend to heights of from 10 to 20 miles, therefore well up into the stratosphere. It will secure data in all conditions of weather, thus overcoming a serious handicap to which all other methods are subject. Finally, it will give those data immediately while the balloon is ascending instead of two or three or more hours after the sounding is completed.

Nor will the benefits be limited to knowledge of the upper air. These instruments, or apparatus based on the same principle, can be placed on small islands—for example, in the West Indies and Caribbean Sea—to give data of inestimable value during the hurricane season. The same use can be made of the apparatus on islands in regions which are subject to destruction by typhoons.

It is generally recognized that great benefit will result from more detailed information regarding conditions in the polar regions. Such information will be secured through the organization of a network of stations in regions where man does not live. It will be perfectly feasible to install the equipment which will transmit the data as frequently as desired, and which can be kept functioning through only very rare inspection visits by means of an airplane.

Again, much thought is being given at present by practically all meteorological services to the desirability of taking up mountain observatory work more actively than ever before. The great difficulty is that establishing observatories on very high summits involves many problems and large cost. The radiometeorograph will solve this problem also, and at comparatively small expense.

The possibilities for the use of the principle of the radiometeorograph or the "robot observer" are, in fact, almost endless and abundantly justify all the feverish activity that is now in evidence in many countries in bringing the equipment to a point where it can be used in regular service.

Present Trends in the Development of Meteorological Service

The subject of communications, particularly radio has been treated at some length partly because it seems appropriate to pay tribute to the electrical engineering profession for its contribution to meteorological service and partly because the rapid development of communication facilities makes possible a corresponding extension of the observational field, both in the horizontal and in the vertical. Hand in hand with these advances have come improvements in instrumental design, in the training of personnel and in international standardization of codes, units, symbols, and definitions, with the result that data from all sources are becoming progressively more accurate and are directly comparable, in addition to being promptly transmitted. Thus, meteorological services are being provided with the working tools that are essential for the development of those services in line with two chief present-day trends which are:

First, the application of sound physical laws to forecasting, displacing empirical methods on which until recently, owing to lack of sufficient data, dependence was necessarily placed.

Second, the organization of a more detailed and intensive type of service to meet the specific needs of individual interests and activities than has heretofore been provided.

Physical Basis of Forecasting

As has been mentioned already, attempts to use simultaneous reports from a network of stations as a basis for forecasting were made very shortly after the telegraph became available, but it was not until about 1870 that official meteorological services were organized by the various governments. Since that time chief dependence has

Observatory on Mount Washington, N. H., 6,290 feet above sea level

been placed on the well-known synoptic map, which shows the geographic distribution of the meteorological elements and their changes from day to day. It is well known that weather conditions travel in a fairly regular manner, altering more or less as they move, and it is possible, from a detailed study of past synoptic charts, to estimate from a current map the changes that will take place during the next day or two in the location of cyclones or "lows" (regions of relatively low pressure) and anticyclones or "highs" (regions of relatively high pressure) and in the accompanying weather conditions that are characteristic of these pressure formations. Much progress was made during the early years of use of this method, but, being empirical, a "dead line" of dependability was presently reached beyond which further improvement is not attainable.

During this early pioneer period many theoretical investigations clearly established the fact that it is not the cyclones and anticyclones as such that are important in determining weather, but rather the interactions between the various air masses that go to make up those systems of high and low barometric pressure. These air masses from different source regions, polar, equatorial, continental, and marine, have distinct characteristics of temperature, humidity, and movement, and they tend to maintain their individual identities over comparatively long periods of time, with the result that at their surfaces of contact they form more or less marked discontinuities or "fronts." It is along these frontal surfaces that the processes involved in weather phenomena are most active, and the study of them, now generally referred to as "air mass analysis," already has proved itself a powerful aid in developing forecasting along sound physical lines.

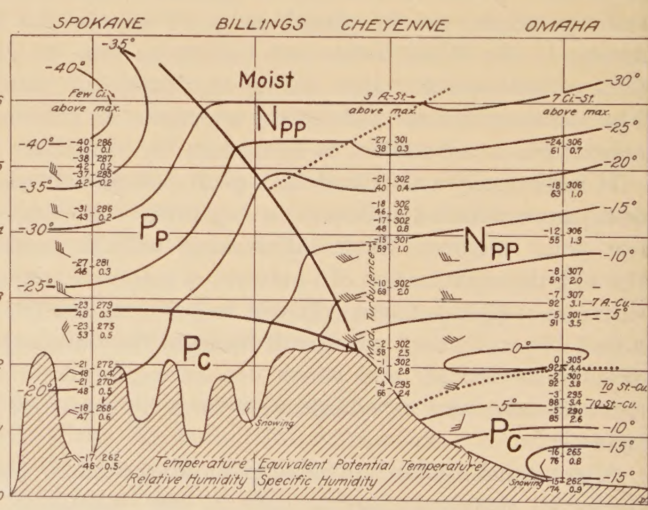
The introduction of a new technique, especially when it involves the use of data of a type not previously available, requires careful study to determine the most effective means of presenting those data for rapid and thorough analysis. The "raw" observational material is useful in showing the current state of the individual meteorological elements, but offers little aid in an understanding of the energy transformations that are taking place. For this latter purpose various so-called "energy diagrams" have been devised which bring out clearly the more prominent characteristics of the air masses that are present and give a picture of the structure of the atmosphere as regards its temperature, humidity, and other conditions.

Adiabatic Charts

The adiabatic chart is the fundamental diagram for plotting the data from individual ascents. The sounding is plotted with temperature as abscissa, and pressure on a logarithmic or exponential scale as ordinate which is approximately equivalent to a linear altitude scale. On the diagram may be located the various temperature inversions (atmospheric strata in which the temperature increases instead of decreases with height) which are significant as marking the tops of turbulent and convectively-stirred regions and which also coincide with the tops of haze, smoke, and cloud layers. Furthermore, these temperature inversions, especially if accompanied by inversions in the vertical distribution of moisture, may signify the presence of frontal surfaces. Adaptations of the adiabatic chart have been devised, from which the energy realizable for vertical convection can be determined—one of the few precise physical computations that can readily be applied to forecasting and which is of great value in forecasting local showers and thunderstorms. The procedure consists in following the changes that would occur were an isolated element of surface air forced to move upward along an adiabatic line, and comparing its temperature, and therefore its density, at each level with that of the surrounding atmosphere through which the element is forced to rise; the conditions in the surrounding medium are given by the data of the airplane observation. If the isolated rising air finds itself in an environment that has a lower temperature, then it will not be in stable equilibrium and will be accelerated upward, thus being capable of producing the strong ascending currents necessary for the formation of thunderstorms. In its ascent the air, after reaching the condensation level of its water vapor, cools at the so-called saturation or pseudo-adiabatic rate, which is less rapid than the adiabatic cooling rate before condensation because of the gradual release of the latent heat of vaporization in the cloud. A convective-energy diagram called an "emagram," based on the adiabatic chart, with temperature as abscissa and pressure as ordinate, is highly useful, since it shows, by its so-called "positive area," the amount of energy that is available for convection.

Vertical Sections

Another valuable form in which the upper air conditions can be quickly visualized is by means of the so-called "vertical section" which shows observed and equivalent potential temperatures, relative and specific humidities, winds, clouds, and so forth, as ordinates and a geographic



Vertical section for Spokane-Omaha on February 13, 1936, showing inflow of polar Pacific air aloft as cold front over polar continental air

Cold front shown by heavy solid lines, warm front by dotted lines, and isotherms by light solid lines. The meaning of the figures grouped around the marked positions on the vertical lines is shown by the model at the bottom of the diagram

section of the country, west to east, north to south, or any other direction, as abscissa. Necessarily the vertical scale is greatly exaggerated. Several such vertical sections are required to show the conditions for the entire country. As yet a method has not been devised that would combine all into one chart, nor is it likely that it ever will be. However, a study of these vertical sections, together with the surface weather map, enables one to form a fairly comprehensive picture of the distribution, both horizontal and vertical, of the various air masses and of the surfaces of discontinuity separating them.

Isentropic Charts

One of the most recent and most promising advances in charting the upper air is the development of the so-called isentropic chart. This method is based on the fact that in the free atmosphere, most movements are along adiabatic or isentropic surfaces, that is, surfaces of constant potential temperature; potential temperature is defined as the temperature attained in an adiabatic reduction of pressure to 1,000 millibars (one million dynes per square centimeter). Instead of drawing charts of the air currents on level surfaces, or surfaces of constant height, the circulation is charted along the isentropic surfaces, which normally are sloping surfaces, and thus the currents are followed along the surfaces on which they actually move. The paths of the air currents can be traced by following the course of "tongues" of water-vapor maxima that appear on the charts. These moist tongues, especially where they are carried in currents moving rapidly upward along the isentropic slope, are correlated with areas of precipitation and cloudiness. In forecasting the behavior of these tongues, one can arrive at a very good idea of the future course or development of precipitation areas. A study of these charts has shown that the atmospheric circulation tends to break up into much smaller eddies than was previously supposed to be the case. New theories of the general circulation of the atmosphere are being developed from these findings.

Practical Results

Now the question naturally arises, what are the practical results thus far achieved? In answering this question one must bear in mind that two or three years constitute a very short period, and one should not be discouraged if the results are no more than suggestive of what may be expected from further use of any new method. Happily, however, in the present case there are some results that are not merely suggestive as to the future but which show definite improvement along some lines already.

It was early recognized that air mass analysis would find its most effective application in the short-period forecasts such as are required for the safe and efficient operation of activities along the airways. Within a year after the introduction of frontal analysis in the Weather Bureau the practice was adopted of transmitting over the airway teletype system information as to the location of fronts, and these have been placed on the weather maps that are prepared several times daily at all airport stations. It is well known that material improvement has resulted in the general character and accuracy of this type of forecast, as is abundantly attested not only by officials of the bureau, but also by the recipients and users of the forecasts themselves.

Can as much be said in the case of the longer period, that is, the regular 24- to 36-hour forecast? Not to the same extent as yet, but there are certain definite results already and they are all in the right direction. They show that the original plan to integrate the analyses and their applications to forecasting with the already existing forecast procedure and with the accumulated knowledge and experience in the past has, even in the short period thus far devoted to its development, made considerable progress in the forecast service at the central office in Washington. For more than a year now the intermediate weather maps that have been analyzed in detail by the trained personnel of the air-mass section have been furnished as a guide for quick and reliable analysis on the principal morning and evening maps by the forecasters. The forecasters report that "this helps materially in readily locating the fronts and identifying the different air masses on these maps. Therefore, the forecasts are always expedited and at times are issued with more confidence because of greater assurance of a correct analysis of the current map."

With wholly inadequate funds for research, with not even enough for the barest needs of current service, for that matter, progress necessarily is slow but it is positive, to a degree that has justified an extension of the program to field stations. A beginning along this line was made several months ago, through the detail of an official in the air-mass-analysis section to important forecasting centers in the airway service. In the meantime several young men who have received special training at the central office and have returned to field assignments are passing on to others some of the knowledge they have gained.

Specialization in Forecasting

All of this leads naturally to a consideration of the second chief trend in the development of modern meteorology, namely, providing a more detailed and intensive type of service, including forecasts, to meet the ever increasing demands incident to the initiation of new activities, or the expansion of already existing activities, in our present complex social and economic structure. Until comparatively recent times a generalized type of service was accepted as reasonably satisfactory or, at any rate, as the best that could be had. No one thought very much about a more detailed service. All this is now completely changed. Every activity that is more or less affected by weather; in agriculture, commerce, marine and aerial navigation, demands and, in increasing measure, is receiving a specialized and intensive type rather than the more generalized type of a few years ago. At that time and during the half century preceding it the official of a Weather Bureau station provided service for all types of activities. He was, so to speak, a "Jack of all trades" and, therefore, through no fault of his own, "master of none." Now, on the other hand, specialists are employed

who have had intensive training in a particular branch of the service and devote all of their attention to it. This change is wholly in harmony with the spirit of our own time which, as is well known, is one of specialization to a greater degree than has been any previous age. In conforming to this fundamental change, practically all branches of the bureau's service have been very materially modified and, it is believed, definitely improved. A few examples may be of interest.

Airway Service

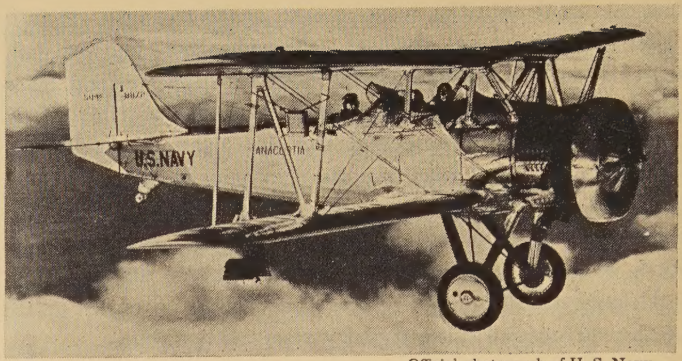
Undoubtedly the greatest impetus to the organization of specialized service was given by aviation. For this activity it was found necessary, in fact vital, that weather reports be available at more frequent intervals and from a larger number of places, both along and off the airways. Certain weather elements not previously measured were essential, such as visibility and ceiling, or height of the lowest cloud layers. Moreover, the general daily forecasts were quite inadequate to meet this new demand. They must be much more detailed and specific and cover a shorter period corresponding approximately to that of the flight itself, namely, from three to five or six hours.

At the same time it was found that certain other aids, such as intermediate landing fields, beacon lights, and prompt communication facilities were required both for safety and for efficiency. A growing recognition of these needs culminated in the adoption on May 20, 1926, of what is known as The Air Commerce Act which authorized the Department of Commerce to provide all necessary navigational and other aids except weather service, this last duty being naturally assigned to the Weather Bureau.

During the 12 years since the passage of this act weather service for aeronautics has undergone a profound evolutionary development, being today specialized to a degree that would have been regarded as wholly fantastic and unwarranted a quarter of a century ago. There are at present some 33,000 miles of civil airways, including those in Alaska and the Hawaiian Islands, and about two-thirds of these on which flying is more or less continuous are provided by the Department of Commerce with 24-hour teletype service. Along these 21,000 miles of airways hourly weather reports are regularly transmitted from stations so located as to provide a complete picture of current conditions and of changes from hour to hour. Intermediate observations also are made when marked changes occur. On airways which are as yet less active and therefore are not provided with teletype service, observations ordinarily are made less frequently, but nevertheless at such intervals as to insure covering adequately all regular scheduled flights.

In addition to these reports from points on the airways others are received every six hours from well located off-airway stations. Two of these collections include data from the bureau's primary or basic system of reports from all first-order stations, from Canada, Alaska, Mexico, the West Indies, and from the oceans.

Of great importance are the measurements of upper air conditions by pilot balloons and airplanes, and, more recently, as previously stated, by radiometeorographs.



Official photograph of U. S. Navy

Airplane with aerograph (mounted on wing) which records weather observations automatically. Observations of this type are made daily under contract with commercial pilots and through co-operation with the Navy Department at a number of points throughout the country. One of the requirements is that the plane must reach an altitude of at least 17,000 feet

Additional information regarding conditions aloft is obtained from observations of clouds, particularly the heights of their bases as determined with small so-called ceiling balloons in the daytime and with ceiling lights at night. Then too there are the reports from mountain stations and from pilots flying along the airways.

All in all, the airway service embraces nearly 800 stations of various types, some providing reports only of surface conditions, others including upper air data also and still others adding to these functions that of maintaining direct contact with pilots and officials of the air transport companies themselves. Of this last type there are now more than 50 stations at the larger terminal and many intermediate airports, where weather maps are made and pilots and others kept advised of conditions in all parts of the country in which they are interested, this service being on a 24-hour basis throughout the year. Eleven of these airport stations are district forecast centers, where personnel of proved technical ability in forecasting also provide continuous service, issuing four times daily forecasts for the next eight hours, with supplementary warnings in cases in which conditions are rapidly changing and differ from the prediction previously made. These forecasts not only are given to those interested locally, but are widely distributed, along with the reports of current conditions, by the Department of Commerce communication system which includes, in addition to teletype, an extensive network of radio stations, thus enabling pilots in flight to be kept constantly informed of current conditions along all parts of their routes and of predicted changes. The forecasts are expressed in very definite terms, with special emphasis being given to ceiling, visibility, line squalls, ice formation, and any other conditions that present a real hazard. They indicate also the upper wind conditions, thus enabling pilots to select an altitude where the flight can be made with the greatest possible speed consistent with safety. As earlier stated, the techniques developed in air mass analysis work have contributed very effectively in improving this branch of the bureau's work.

Such in brief are the main features of the airway meteorological service as it functions at the present time. Only an extreme optimist would claim that it is ideal. It is only about ten years old. During this period there has been much experimentation, with changes and improvements resulting as suggested by experience. There is reason to believe that the basic and essential features are sound and will probably endure, but there are bound to be further improvements as new ideas and methods are proposed and introduced. The Weather Bureau is now actively engaging in many research projects, all designed to bring about such improvements.

Hydrologic Service

Although river and flood forecasts have been issued since 1871, it is only recently that this problem has been attacked with due regard to the engineering phase. This has come about partly because of the series of floods that have brought disaster to many parts of the country and partly because of legislation authorizing a comprehensive program of flood control.

Flood forecasting utilizes two methods which differ markedly in principle. On the larger rivers and on the lower reaches of the smaller streams gauge relations are sufficiently consistent to permit an accurate estimate of expected stage far enough in advance to make adequate preparation for evacuation of areas doomed to inundation. Forecasts are developed progressively downstream, properly adjusted to increase in flow from important tributaries. The period covered by the forecasts ranges from two or three days in the upper valleys to as much as three or four weeks in the lower Mississippi Basin.

As the headwaters are approached, however, prediction of river stage becomes increasingly complicated. The amount and rate of the rainfall, the slope of the land and the stream channel, the character of the watershed and its cover, and the influence of antecedent rainfall—factors which have been integrated into terms of stage on the lower river—now become variables which must be dealt with separately and quantitatively.

This nation is rapidly becoming flood conscious, with the result that the Weather Bureau has been forced to extend its river forecasting service into the headwater areas of nearly all the principal streams. There has been neither time nor opportunity to prepare for basic changes which involve method and procedure wholly without precedent. At many important up-river stations, the forecaster has only a comparatively few hours to foretell the approach of a flood and that under the conditions of "flashy" stream flow typical of headwater tributaries. Pittsburgh is perhaps the best example of such a situation. Any plan to meet this problem must be prepared to predict flood stage practically as the rain falls and the snow melts. The city itself must be organized to evacuate certain areas with the precision of a fire department. Industry and business occupying danger zones must plan to waterproof against the rising water or to remove damageable goods to higher levels on minimum notice. This city, and other municipalities so situated, must maintain stand-by emergency water supplies and lighting facilities. Permanent concentration centers must be selected in advance and emergency housing provided. These and other plans in considerable detail are being formulated by the agencies charged with the responsibility of dealing with great floods.

The flood of January 1937 in the Ohio and lower Mississippi rivers illustrates the application of both approaches to the problem of flood forecasting. The forecasts for the Mississippi, for example, were almost entirely on the basis of upstream stages. Those for the Ohio on the other hand were based in considerable part on the occurrence of the heavy rain that prevailed for the greater part of the month, causing the upper river to crest 24 to 36 hours after the rain ceased.

In order to meet these rapidly increasing needs it has been necessary to reorganize the hydrologic branch of the service so as to bring about a much closer co-ordination with agencies in charge of flood-control programs and to permit greater participation in fundamental research. To this end the country has been divided into 12 hydrologic regions, 5 of which are now provided with regional offices and personnel. The regional offices are being manned by qualified hydrologic engineers who will gather data, develop methods of estimating stream flow, devise means of assembling flows, and co-ordinate and unify the forecasting program.

As rapidly as funds permit, the network of recording rain gauge stations is being extended. Increasing attention is being given to the accurate measurement of evaporation and special studies are being made to determine basic relationships between snowfall, snow-melt, temperature, ground-surface conditions, and runoff.

A research project which is believed to be of very real significance is one that is now being conducted co-operatively with the Corps of Engineers to estimate spillway and waterway capacities. The procedure is to make a detailed study of major storms that have resulted in excessive precipitation and floods, transpose these storms within reasonable limits to other locations with respect to nearby river basins, take other factors such as topography, snow cover, and a different temperature distribution into consideration, and endeavor to determine what is the maximum runoff that is ever likely to occur. This is a direct application of the work that is being done in air mass analysis, the isentropic chart, previously referred to, playing a prominent part. It is planned to extend this study to all of the principal river basins in the country.

Hurricane Warning Service

Another good example of present trends is the hurricane warning service which was materially strengthened three years ago. The main features are: (1) a 24-hour teletype service connecting points along the Gulf of Mexico and south Atlantic coasts, from Brownsville, Tex., through Key West to Jacksonville, Fla., thus providing for frequent exchange of reports and prompt transmission of forecasts; (2) an increase from two to four reports daily from ships in the Gulf of Mexico, West Indies, and Caribbean waters; (3) close co-operation with the Coast Guard; and (4) the assignment of specialists trained in

In the wake of a hurricane. Warnings issued by the Weather Bureau of the approach of these destructive storms are of inestimable value to shipping and many other interests

hurricane forecasting to New Orleans, Jacksonville, and San Juan.

Along with the development of this service there has been organized, co-operatively with Massachusetts Institute of Technology, a research project which consists in sending up recording apparatus, attached to balloons, during the passage of hurricanes, preferably as near their centers as possible. Only a few records thus far have been secured, but they show some interesting features regarding atmospheric structure in the upper portions of these storms. This investigation is being continued in the hope, not that hurricanes will occur but that, if they do occur, we shall obtain information that will increase our knowledge of their characteristics and thus enable us to forecast their formation and movements more accurately.

Research

Time does not permit consideration of many other examples of the present tendency to specialization of service. In all of them, as well as in those that we have discussed, research is playing an increasingly important role. A broad comprehensive research program is in fact fundamental to any future progress. The Weather Bureau is limited as to funds for the development of such a program, but fortunately the Bankhead-Jones Act for research in the Department of Agriculture makes possible a definite beginning along this line. Only brief mention can be made of a few of the more important of these projects. One of them is an investigation of the conditions which give rise to the building up of huge domes of polar air in Alaska, these later moving southward and developing into the cold waves that invade and spread over large sections of this country. Upper air soundings with airplanes and radiometeorographs, together with measurements of outgoing radiation, have been made at Fairbanks, Alaska, Fort Smith, Canada, and at points along the northern border. Already some significant conclusions have been reached, although it is too early to announce any definite results.

Attention is not being limited to winter conditions, however. Equally important, in some respects more important, because of their relation to agriculture, are studies now in progress to apply air mass analysis methods, and particularly the isentropic chart, to the forecasting of thunderstorms and precipitation generally during the summer season. The number and frequency of upper air soundings are not yet adequate for this investigation, but the results thus far nevertheless give a substantial basis for optimism that forecasting of summer rainfall, including thunderstorms, will be materially improved and that the period of the forecasts can be extended to something like five days, possibly longer.

An investigation of considerable promise has to do with solar variations as they may affect the atmospheric circulation, and special attention is now being given to the question of atmospheric ozone as a possible link between solar activity and changes in the circulation of the atmosphere. Measurements thus far made show that ozone is greatest in amount a short distance to the rear of low-pressure centers and least in the corresponding part of high-pressure areas. It would seem then to be a valid assumption that the variations in the amount of ozone are related not to the barometric pressure itself but rather to the sources of different air masses, the ozone being most abundant in polar and least in tropical air. There is thus the possibility of utilizing the measurements of ozone and its variations in forecasting the development and movement of the different types of weather that are associated with fronts, anticyclones, cyclones, etc.

Many other problems are being attacked in a very definite way, such as the conditions that produce ice formation on aircraft and widespread sleet and ice storms that cause so much damage to power lines. The hazard of lightning to aircraft is now receiving special attention. Nearly all of these investigations are being conducted co-operatively, in part with other government agencies, in part with educational institutions, and in part with interested individuals. Meteorological services of other countries are likewise active. It is in fact one of the hopeful signs of the times that research is assuming its proper place in the development of modern meteorology.

New Outlook

Attempt has been made to outline briefly some of the main features of the present program of reorganization of the Weather Bureau designed to bring about improvements in the service, including particularly forecasting. It may be noted that much of this relates to the future. Nevertheless, very real progress has been made in some lines already. The point of real significance is that a break definitely has been made away from an ultraconservative attitude, from dependence on old established methods, and the service is being developed in line with modern scientific thought and procedure. Encouraging results already are being realized; others are bound to come as the program is continued and extended.

Labor Policy and Employment

By LEO WOLMAN

Maladjustment brought about primarily by too speedy reform is cited by this noted economist as one of the principal causes of the present long-range trend toward increased unemployment. Speaking of various industries, he expresses the belief that unemployment persisted in certain industries during the recovery period ending in 1937 because those industries had not made sufficient technological advance.

WHEN examined as a long-term problem, unemployment everywhere in the world seems to be getting bigger; and that began right after the war. It is higher, of course, in the depression than it is in the subsequent recovery, but in the subsequent recovery it is higher than in the preceding recovery.

Now, that is a very important thing if true. I want to rule out some countries in considering this trend. I won't include Germany, Italy, and Russia, not because they have no unemployment but because we can't get the figures that we are able to get from other countries, notably England and the United States.

In these two countries unemployment seems to have moved something like this: Before the war the unemployment rate in England was about five per cent. During the war, of course, everybody was employed except the unemployables, and the unemployment rate descended to an unprecedented low level, and then after the war came the *depression*. From 1922 to 1930 the British had an unemployment rate of ten per cent. These are rough figures—I am quoting from memory—but they are close enough to the truth to be useful.

So in the *recovery* of business in England in the 1920's (I am ruling out the 1921 depression) the British unemployment rate was two times the prewar rate. During the depression of 1930 the unemployment rate shot up again to a great height, but I am not dealing with depression periods because everybody knows there is more unemployment in depression than in prosperity. So I go to the next prosperity period, which in England began in 1932, and which gave some indication of being on the verge of terminating October 1937. At any rate the unemployment rate began to go up in October 1937, and its spring recovery was not as great as spring recoveries have been before. But if you chart these turns, their curve turned in the fall of 1937. If you take their recovery years 1932 to 1937 and estimate the unemployment rate through that whole period, you will find that it runs about 13 to 14 per cent.

This is an extraordinarily important series of figures. A 5-per cent prewar unemployment rate, a 10-per cent postwar prosperity unemployment rate, and then a 13-per cent post-depression unemployment rate in the latest recovery of business. And the recovery of business was very healthy in England, where industries that had long been depressed, like textiles, iron and steel, and shipbuilding, had a great deal of activity and foreign trade prospered again.

Now, I want to discuss briefly what is meant by minimum unemployment rate. We know that it was once the rule that all or practically all of the unemployed were absorbed during the prosperity that followed depressions. But in England from 1920 to the present that does not seem to happen. Not only doesn't it happen at all that most of the unemployed are absorbed, but apparently, in other countries as well as England, during each recovery, the unemployment rates ascend to a plateau and stay there.

Trend in Unemployment Rate

I don't for a moment believe that this trend is going on without end, but what I am afraid of, and do almost believe, is that England and other countries, including the United States, will settle down to a relatively high unemployment rate of that kind, even during periods of prosperity.

Employment statistics in the United States historically aren't as good as the British, but we began to get them in the 1920's; we did better than England in the 1920's and we had a lower unemployment rate then. I want to talk about that in another connection later, but our interesting history begins in 1933 from this standpoint.

Beginning 1933 you will remember, we had signs of a business recovery and there were certain hesitations and certain turns in the business curve, but business activity continued to ascend until—authorities differ on this—the end of 1936 or beginning of 1937. The year 1937 as a whole was pretty good, and then the curve began to descend. So we had a period of about four years of prosperity and when you look at the unemployment figures, putting the best face on unemployment and the worst face on it, taking the figures of the National Industrial Conference Board on the one side and the American Federation of Labor on the other, we settled down in this period to a volume of unemployed of about seven million. Now, seven million gives a pretty high un-

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Essential substance of an address presented at the first public forum held May 13, 1938, in Philadelphia, Pa., by American Engineering Council, on the subject "Employment and the Engineer's Relation to It."

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employment rate—say about 14 per cent. That is an unusually high rate for a period of prosperity.

Students of this problem began to come to the conclusion that we are probably in for that sort of thing for some little time to come. The great danger confronting countries like the United States and England is that in the period of recovery the unemployment rate will remain relatively much higher than formerly and possibly higher than it was during the last period of prosperity.

Anybody who is familiar with our ways of dealing with the unemployment problem directly knows that the persistence of a relatively high rate of unemployment is at the root of the most fundamental and troublesome of our economic problems today. To this problem of dealing with unemployment we can trace all our big national economic problems—unbalanced budget, heavy and expanding public expenditures, currency problems, credit and banking problems, problems of floating the national debt, the charges imposed on business by way of taxation to take care of expanding expenditures, and the whole series of questions like that.

Methods of Dealing With Unemployment

How do you deal with unemployment? There isn't any mystery about it. You don't have to be an economist. We have had a long history of dealing with unemployment, and I'd like first to mention the formal methods. There are three methods of dealing with the unemployment, barring economic planning. Economic planning is essentially, after all, only saying you would like to regularize business so you won't have unemployment. Economic planning is partly a statement of wish. Barring that approach to the question we have had several pretty well defined, simple ways of dealing with unemployment.

When the British Poor Laws Commission made its report in 1909, it agreed on three things that should be done: first, an increase in public works in time of depression to give some work to the unemployed and give a fillip to business; second, the organization of a national system of employment exchanges so that the labor market, which is a disorganized market, will become an organized market and employers will be brought closer to employees; and third, unemployment insurance.

I don't think we in the United States have gone much beyond that. The British Government has organized a system of employment offices since 1909, and they have been in operation since then. We are in the act of organizing a national system of employment offices. The British have had a universal system of unemployment insurance and have used public works.

These are the three traditional methods of dealing with unemployment. We have used them and it is pretty clear to everyone now that they are not solutions. They are not solutions in the sense that the application of these measures to the unemployment problem will result in a reduction of the volume of unemployment, because, after all, the real solution or approach to the unemployment problem is the application of a method which leaves the country with a smaller volume of unemployment than it had before.

It is true that if you have persistent unemployment, the use of employment offices for re-employment and work, and unemployment insurance may alleviate the difficulties; but it is pretty clear by this time that it doesn't reduce the volume of unemployment.

I turn then from this introductory statement to what it is that people think this unemployment is due. What do the people believe about unemployment? Well, one group believes it is due to one simple thing. They trace the increase in the volume of unemployment in this country (though they don't speak about other countries) to the increasing acceleration in the use of technical invention in industry and to the phenomenon associated with that—the increasing productivity of labor. This is a scientific problem I'd like to talk about, not from a theoretical point of view because that would take too long and take us farther afield than I am in a position to go at this moment.

What about this increase in technology? What kind of evidence is there to support the view that a serious unemployment problem grows out of the accelerated rate of application of invention to industry?

There are all kinds of evidence; there are many approaches to this question. I'd like to say one word first about how to measure these things. The measure of the increase is what we call the "productivity of labor," and this is measured in a direct way. You get a measure of physical production and you compare that measure of physical production with the number of people employed to get a measure of per-capita production. If you do that over a long period of time you have a comparative measure.

Another, and better, measure is to compute the amount of production per man-hour. Hence, in economic writings we have these two measures of what might be called the efficiency of labor—physical output, and man-hour physical output.

The trouble with those measures is that they are new and comparisons cannot be extended very far back in the records of economic history. That is a common scientific difficulty. It is going to take a long time before the records will reach back far enough and in good enough shape to make them comparable with contemporary records.

The History of Wages

I have been working on the history of wages in the United States from 1890 to date and I find my figures are better from 1914 to date than they were from 1890 to 1914. But I am interested in the period 1890 to 1914—a period of very bad depression and a business recovery; and as a scientific and economic historian I'd like to know how wages behaved in the depression of the 1890's, and in the recovery of that period, so that I can compare the recovery wages with wages in 1921, 1930 to 1933, and so on. It is going to take a lot of work and money—the same sort of work that the men in the natural sciences had to do before they built up their systems of measurement—before we can write the wage history of the United States from 1890 to 1914 and particularly from 1890 to 1900.

The same thing is true in productivity measures. We don't have a long enough series that is comparable over a long enough period of time. Another difficulty is this: Physical output is compared with the number of people employed. Well, the first thing any man that knows his methods of measurement must do is to make certain that he is comparing a physical output that was produced by employees for which he has an employment measure. Now, if I am comparing the physical output of one group of employees with the number of employees in another group, then I do not have a satisfactory final measure of the per capita physical output in the United States.

If you examine the unemployment figures for the year 1929, you find we have a moderately low unemployment rate. From 1922 to 1929 was a period of enormous rise in the productivity of labor and, however measured, the net cumulative effect at the end of that period, before we went into the depression, was a relatively low rate of unemployment. It was about four per cent, and it was really lower than that because in the United States we have decided changes in seasonal employment.

Now, I don't know what the normal rate of unemployment is in the United States; but with a gainfully occupied population in 1929 of about 50 million, a rate of four per cent or two million people, part of whom were—and I might say 30 per cent, anyhow—seasonally unemployed, is not high.

So, in my judgment, the technological problem that we had in the United States from 1922 to 1929 was a relatively moderate one. Given prosperity, without the great volume of unemployment associated with business depression, and the handling of that problem of displacement through the introduction of machinery was a relatively minor problem for a rich and going economic concern to deal with. It is true that we didn't deal with it and didn't have machinery to deal with it, but from the standpoint of analysis of the problem it was a perfectly practical thing to deal with and could have been dealt with, and not expensively.

Relation of Employment to Production

In a report of the National Resources Committee on technological change in the United States it is estimated that in order to absorb all the unemployed in the United States in 1937, in view of the great changes in the productivity of labor, it would be necessary to have a volume of production 20 per cent greater than in 1929. That is probably true. Every time we have had a business recovery, our index number of production ascended to a substantially new and higher level. The recovery from 1933 to 1937 was the first of which we have any record in which the index number of production did not exceed that in the preceding period of business recovery. It is also the first period of business recovery of which we have any record in the United States in which most of the people unemployed were not absorbed during the period.

One way to find out whether this continuing large volume of unemployment in 1933 to 1937 was due to technology is to find out where it is. That will not give a final answer, but it may throw some light on the problem. Does it exist in industries that have made great technological strides forward and in which there has been a great increase in the productivity of labor, or does it exist somewhere else? Well, I haven't made a careful study of this, but I have looked around, and I think that the unemployment we had in the recovery period 1933 to 1937 was in depressed industries—not in industries that had made great technological advances but in industries that stayed depressed. And while I don't know as much about these industries as I'd like to know, I am tempted to state this conclusion: they were industries that had not made sufficient technological advance. I might say that if they were industries that had been able to attract more capital and had then applied more invention to their operations, and so increased the productivity of their workmen, they would have employed more people than they did and we would have had a net lower volume of unemployment from 1933 to 1937.

Let us look at a few of those industries, because they are interesting in a number of ways.

First were anthracite, railroads, and building construction, and I associated with them subsidiary industries. I calculated their payroll during the expansion period 1933 to 1937 and compared it with 1929. So I had for each of these industries figures that told me how much payroll these industries yielded to labor in this country in this last recovery compared with the last year of the previous recovery, 1929. They are extraordinarily interesting figures.

The anthracite industry paid out in wages during this period of prosperity half what it did in 1929; railroads paid out $57^1/_2$ per cent, and building construction, with all of the recovery we had up to and through 1937, paid out 35 per cent. The deficiency in anthracite is 50 per cent, of the railroads 43 per cent, and in building 65 per cent. Those are big deficiencies, and nobody for a moment will look at these industries, particularly the building industry, which is one of the two largest of this group, and say the trouble here is that people are working too fast, that their productivity has gone up too fast.

I don't want to take too much time on this, but we ought to consider the fact that back of the building industry are other industries that go up when building goes up—manufacturing industries as well as those occupations and services that are associated also with the prosperous industries. Of the associated manufacturing industries, the lumber industry employed 500,000 people in the United States in 1929—a big industry, as big as textiles. Its payrolls were, from 1933 to 1937 on a 1929 base: mill work, 40 per cent; saw mills, 40 per cent—a 60-per cent deficiency. So there is the picture. I haven't made a canvass of all these directly affiliated industries, not to speak of those indirectly affiliated, but I can attribute a great share of the volume of unemployment to industries that saw no technological improvement and in which unemployment persisted for the simple, traditional, and ancient reason that there wasn't any business.

So we are back to our old problem of why there isn't business. The technological advance isn't going to explain it. A study of unemployment in England won't ex-

plain it at all. What is it all due to? Maladjustment! That is the key to the problem—maladjustments, dislocations. A competitive society is an integrated society. If it isn't, it just doesn't work right. The character of the integration isn't simple, but we know something about it, and we know that if some parts of it get out of gear the efficiency of the whole machine may be reduced. Some of the dislocation and maladjustment in our machine couldn't be helped. We might have handled it a little better, but it was a difficult problem and it unquestionably has been a source of a great deal of unemployment. I am referring to the dislocation and maladjustment that arose internationally.

We have had a serious, severe, fundamental, persistent, long-time maladjustment that unquestionably reflects itself in an increase in unemployment in the United States and in other countries. If you look at the British system there is no doubt that a portion of the unemployment arose out of the changed international situation. Why do we have so much agricultural unemployment? One reason is that our position in the world markets is changed. But I want to talk about maladjustments closer at home and to look at them in broad terms.

Rapidity of Social Changes

During the time of the industrial revolution (certainly in the 19th century) with its changes in the methods of production and the growth of a wage-earning class, and all of that complexity of change that took place in England, the United States, and Germany, some other things happened. There were social movements associated with these economic changes. One of these was the trade-union movement. Another phase of the social movement was a growing interest of government in social conditions, in economic conditions, particularly in the economic conditions of employees. So the period from 1850 on to a large degree in Germany, to a larger degree in England, and to some slight degree in the United States, was characterized by the growth of instruments of reform the purpose of which was to stop exploitation, as it was called, to reduce the hours of work, to raise real standards of wages, and so on.

Now, if you look at those instruments and really take a broad view of their history, up to the war, I think you will find one interesting quality they all possessed: they all concerned minorities. The trade-union movements were of minorities, not only in the United States, but in England, Germany, France, and all industrial countries. And while they had some power, you can't talk about their power in the same terms as the sort of power they have possessed since the war. They were minority movements with definite workable restrictions on what they could do for better or worse or for good or ill.

The labor legislation that was applied had also a distinguishing quality. It was applied slowly and the changes it brought about were relatively slight changes. Look back over the history of wages and you will see the changes were very slow and were moderate. You can measure these things by looking at a country like England, where the hours of work in manufacturing industries even now are about 49 a week. But before the war the striking fact about these historical developments was that they were slow and moderate, and if you could have translated them into cost, their cost couldn't have been great. They were always applied to an industry that was expanding. That was true in the United States, England, and Germany, and in some measure in France. Thus, the conclusion one would draw from that history is that these efforts to control through trade unionism and labor legislation were of such a character that there wasn't any question that they could be easily absorbed by the economic system. That is all, and I think you can draw the general conclusion, if you look at an economic system as a going concern, that if you reform it carefully and in moderation it will stand a great deal of reforming; but if you reform it recklessly and without moderation your reforms probably will do a great deal more harm than good.

I think the character of reforms before the war was slow and moderate; and while there may have been occasions when they were difficult to absorb, taking the period as a whole they were easily absorbed. The reforms we have had since 1920 have been of just the opposite character, and the probabilities are that they will take a very long time to absorb.

I don't want to give the impression that this is the whole story, but it is a big part of the story. If the failure to run smoothly can be traced back to the rise and growth of dislocations and maladjustments of this kind, the speed with which we have applied these reforms—and they are costly reforms to the system—is one of the several fundamental causes of this failure to run smoothly and failure to absorb reforms.

All you have to do is take a look at them—the NIRA, all the labor boards, the Bituminous Coal Conservation Act, universal unemployment insurance, universal old age—I am using "universal" broadly, covering a large part of the population—numerous grants in aid, a federal system of relief, and public works. I have probably forgotten some, but that is a pretty big bite to take of reform. Somebody pays for these things and they entail burdens. Burdens of that kind imposed over a period of time can be absorbed with a minimum of dislocation and maladjustment and therefore of unemployment. Imposed in a short period of time they become hard to absorb.

We have measures of these things, and I think we are going to come closer to an understanding of these problems if we are able to translate some of them into magnitudes. Most people have had some business experience and can see how it becomes necessary to absorb these items of cost as we go along, and not only to absorb them at one time but to adjust them at another time. For example, when a business passes from a period of prosperity to a period of depression, one of the great problems is to adjust itself to this new type of business condition. I would like to give a few figures about manufacturing wages in the United States, and they are about as accurate as we have.

The manufacturing industries of this country, when things are going well, employ about ten million people, which is about 25 per cent of the total gainfully occupied.

When they are not going well they employ about seven or eight million people. So when you are studying wages in the manufacturing industries you are studying the wage of a large segment of the working population of this country. Eighty per cent are men, twenty per cent women, and industries covered in manufacturing run all the way from printing and publishing houses and rubber-tire industries, automobiles—in which wages are very high—to the canning industry, to the cotton-goods industry—where wages are relatively low. You can't talk generally about high and low wages in this country. They have got to be related to some standard. What do I mean by standard? American wages are high or American wages are low; obviously I have different things in mind. If I say American wages are high I mean, among other things, that they are high compared with what people get in other countries. I may also mean compared with what people used to get here.

Here are some figures of movement of wages in the United States in manufacturing industries: These ten million or so people were paid 25 cents an hour in 1914. They got 61 cents an hour in 1920. They got 59 cents an hour in 1929. At the bottom of the last depression, 1933, they got 45 cents an hour. And in December 1937, they got 72 cents an hour. That is a very important set of figures. In December 1937 manufacturing labor in the United States got, roughly, three times in money wage what it got in 1914. It got 11 cents an hour more than it got in 1920, which was the all-time peak of money wages in this country, and a peak that was reached after a very lively period of business from 1914 to 1920. And it got 13 cents more than in 1929, which was another peak in American business. It got 27 cents an hour more than it got at the low of the depression in 1933.

They are startling figures, and they are quite representative of wages generally. The only industries where wages have not moved like that are those in which labor got little reduction during the depression—railroads and coal.

Comparison of Real and Money Wages

Money wages should be translated into real wages because everyone knows that money wages lose their meaning in a period of radical changes in the price level. So I have converted these money wages into real wages—real hourly earnings, that is, money earnings corrected for the cost of living.

In December 1937, wages were 72 cents an hour as compared with 61 cents an hour in 1920, and of course, they were higher than in 1929 and much higher than in 1914, because comparing 1914 with 1937 money wages went up threefold and the cost of living went up about 50 per cent, so you have an enormous increase in real wages.

I want to make myself clear about this. I do not think that the population of a country like the United States divides itself naturally into two groups of people, one the friend of the masses, and the other the enemy of the masses, the friends wanting to sustain the so-called wages of labor and the enemies wanting to cut it down. I do not think that is a statement of the problem. When I say that industry has a capacity to absorb and when that capacity is exceeded it ceases to absorb and run smoothly, I mean that when friends of labor seek to put wages at a point where they cease to yield the greatest volume of employment and payroll, a great and perhaps lasting disservice is being done to labor by the very people who call themselves, and probably honestly regard themselves, as the friends of labor.

Now I am not so foolish as to say that I know what that point is, nor that I am prepared to say what wages fixed at that point would yield the highest payrolls to the largest number of employed people; but I think here, as in other cases, the rules of common sense might be applied. There are methods of observation that permit students to look at this situation; and here an excess has been practiced, and most people associated with it would have been better off if the excess had not been practiced.

In dealing with these kinds of problems, sooner or later we must come to grips with this conflict between our political views and our economic views, and there isn't going to be any right thinking, if, when we take the political point of view, we are willing to fall into gross economic error. If we fall into gross economic error that way and stay there, our economic problems are going to multiply and become more serious and more difficult to solve; and among the most serious and most difficult to solve will be this continuing unemployment problem, the persistence of a rate of unemployment in this country, as in England, at a level higher than it ever was before the war, at a level higher than it was in the prosperity period 1933 to 1937.

An Analysis of the Induction Machine

A MATHEMATICAL analysis of the induction machine which is applicable to the solution of a variety of transient and steady-state problems is presented in this paper.* The method was developed particularly to evaluate the performance of induction motors when driving pulsating loads such as compressors.

By means of a set of linear transformations, the phase voltages, currents, and flux linkages are referred to a set of orthogonal co-ordinate axes which are stationary with respect to the stator. The resulting differential equations are not only linear but have constant coefficients for the case where the rotor speed is constant. Such equations are readily solvable by the operational methods. The simplified equations are applicable to any machine with a uniform air gap and balanced, sinusoidally distributed rotor windings.

The treatment is not limited to problems wherein constant rotor speed is maintained. The results are expected to be especially useful in the practical solution of problems due to the excessive current pulsations and light flicker which may result when induction motors are used on pulsating loads.

*Abstract of 1938 AIEE summer convention paper number 38-69, by H. C. Stanley (A'37), which will be published in full in TRANSACTIONS.

Transcontinental Telephone Lines

By J. J. PILLIOD
FELLOW AIEE

Late in 1937 a large construction project was completed which added 16 telephone circuits to the transcontinental layout, and the work was so planned that 48 additional circuits can be obtained by the addition of equipment but without stringing additional wire. A brief description of some features of this project and the general development of the transcontinental telephone routes since the first one was opened for service in 1915 is given in this article. Although most of the discussion relates to transcontinental lines, the methods described are generally applicable to other similar situations.

LESS THAN 25 years ago, it was impossible to talk by telephone from coast to coast across the United States. Furthermore, it was impossible to talk between points separated by any such distance anywhere in the world. By 1915, technological advancement had reached a point such that telephone service could be established across the country, and three telephone circuits had been built which connected San Francisco and the Pacific Coast with points in the East. Four telegraph circuits were also provided by the new wires. An improved loading system and especially the successful development of the vacuum-tube telephone repeater were outstanding factors which made telephone connections of such length possible for the first time in history.

Open-wire lines played the major role in the early transcontinental telephone circuits. The transmission losses caused by cable were so great that it was avoided whereever possible. The steady improvement of telephone repeaters, types of loading for use on cable circuits, and carrier telephone systems for use on open-wire lines made it possible to provide rapidly and economically more telephone circuits across the continent as use of the service grew. In the cross section just west of Denver there are today 140 through telephone circuits and about the same number of telegraph circuits carried by four open-wire routes, the last of which was completed during 1937. While open wire was used almost exclusively as a matter of necessity in the first transcontinental telephone lines, cable is now used for about half of the circuit mileage. This is a striking illustration of the large-scale changes which have taken place in the interest of more reliable toll telephone service.

Continued Importance of Open-Wire Lines

The open-wire line seems destined to continue to play an important part in long-distance telephone communication, particularly where distances are great and circuit requirements on any one route are relatively small. Improvements in the usage to which the wires may be put have made this increasingly so. The three circuits on the first transcontinental line were operated at voice frequencies and were obtained from two pairs of line conductors, the third circuit being derived by means of phantom circuit arrangement of these two pairs. The development of carrier telephone systems made it possible to obtain three additional circuits on some pairs of wires, using frequencies above those required for existing voice-frequency circuits. Carrier telephone systems were first installed on a transcontinental route in 1926 and were quickly followed by others, so that today 96 of the 140 circuits mentioned earlier are obtained by means of these three-channel carrier telephone systems. Development work, however, has been continued, and it is now expected that it will be possible, by means of carrier telephone systems using still higher frequencies, to obtain as many as 12 more telephone circuits on some pairs of wires. It has been with a view toward using such systems and obtaining a total of 16 telephone circuits on a pair of wires that the latest of the four transcontinental routes has been designed.

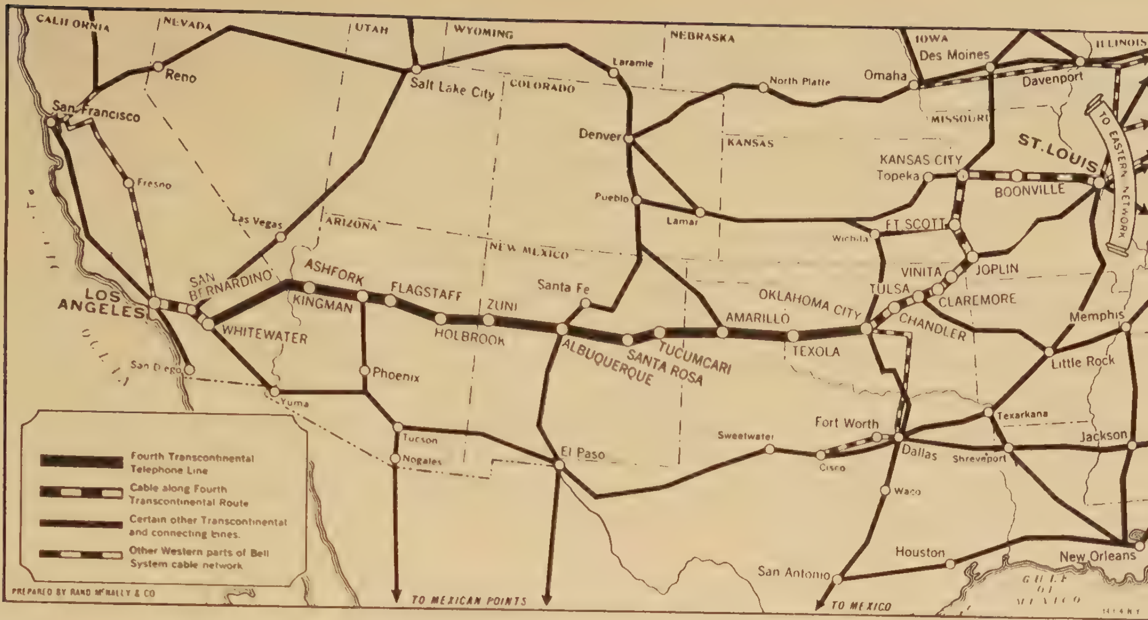
Construction of New Transcontinental Line

Early in 1937, it became clear from a study of loads carried on existing transcontinental routes that additional circuits would be required in the near future. Circuits in cable were available as far west as Omaha, Kansas City, Oklahoma City, and Dallas. After consideration of all the factors, it was decided to construct the new facilities west from Oklahoma City to Los Angeles on the route shown in figure 1. It was also decided to carry out the work in such a way that the route could be utilized for the future addition of a relatively large number of circuits through the application of the 12-channel carrier-current telephone system then under development. Among the conditions favoring this particular route is freedom from winter storm hazards throughout most of the distance, which, looking ahead, is particularly important to the future application of 12-channel carrier telephone systems. The work done in 1937 consisted of building a length of nearly 300 miles of new pole line and stringing four pairs of wires throughout most of the section from Oklahoma City to Whitewater, Calif., a distance of 1,200 miles. Ini-

Essential substance of an address presented before the communication group of the AIEE New York Section, March 22, 1938.

J. J. Pilliod is engineer, American Telephone and Telegraph Company, New York, N. Y. A native of Chillicothe, Mo., he was graduated from Ohio Northern University with the degree of electrical engineer in 1908. He was employed in various departments of the American Telephone and Telegraph Company from that time until 1917, when he entered the long lines department at New York. Since 1920 he has been in charge of engineering in that department. During 1933–37 Mr. Pilliod was a member of the AIEE committee on communication.

Figure 1. Route of new transcontinental line across western states



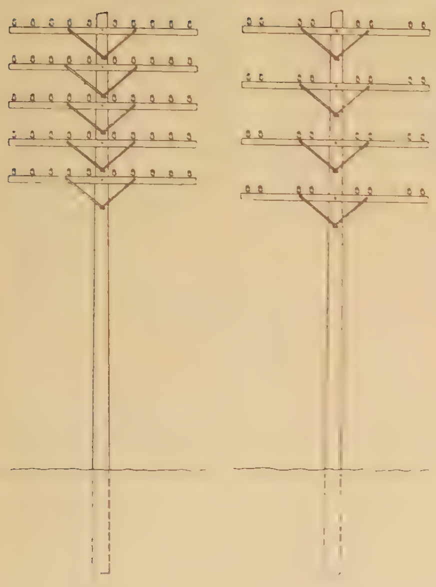


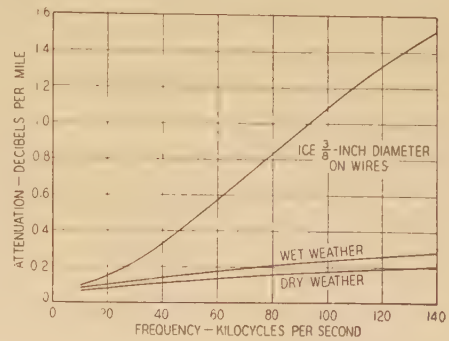
Figure 2. Crossarm arrangements

Left—50-wire phantomed line, capacity 77 telephone circuits

Right—32-wire nonphantomed line, capacity 256 telephone circuits

Figure 5. Attenuation of open-wire pairs

165-mil copper, 8-inch spacing



tially the voice channel and three-channel carrier telephone systems have been developed on these four pairs, providing a total of 16 telephone circuits.

Wire Spacing and Transpositions

Open-wire telephone lines designed to carry frequencies up to 140 kilocycles per second, as used in the operation of the proposed 12-channel carrier telephone systems, have structural requirements substantially more stringent than those designed to carry only three-channel systems, which use frequencies up to 28 kilocycles. The usual type of open-wire toll telephone line has ten wires on each crossarm, spaced at about one-foot intervals, five on each side of the pole and with the crossarms spaced 24 inches apart. In the case of the line designed to conduct high carrier telephone frequencies, this configuration has been changed and is illustrated by figure 2. Eight wires are strung on each arm, grouped as four pairs, two on each side of the pole. The wires of the pair are spaced 8 inches apart, and the nearest wires of the two pairs on each side of the pole are spaced 26 inches, while the spacing at the pole is 30 inches. Crossarms are spaced 36 inches apart.

These new wire spacings reduce the coupling between pairs on the same line or between pairs on this line and pairs on other lines which may parallel it. New transposition systems are used further to reduce this coupling. Transpositions are closer together and a transposition bracket of the type shown in figure 3 is used to turn the wires completely over at as nearly a given point as possible. Transpositions in one or more pairs are installed on every pole with an occasional exception, and certain pairs are transposed at every other pole. The wires of a pair must be adjusted to the same sag within close limits. These sag variations are held to a fraction of an inch, and

(*Concluded on page 423*)

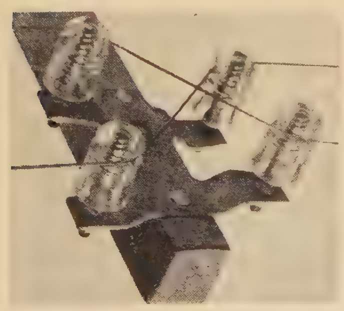


Figure 3. Point type transposition bracket as installed

Figure 4. Flat tie wire shown as installed

Robert E. Doherty — 1937 Lamme Medalist

By A. R. STEVENSON, JR.
FELLOW AIEE

Doctor Doherty's career is a striking refutation of the old adage that "those who can, do; those who can't, teach." For many years his name has been identified with the best among those who "do" in engineering. At the same time he has had an unwavering interest in engineering education, and through his many contributions has risen to a position of prominence in that profession.

ALTHOUGH Lamme and Doherty grew up in rival institutions, there are certain striking parallels in their careers, which make particularly fitting the award of the Lamme medal to Doctor Doherty.

Lamme first won public recognition by making advances in the art of electrical machinery design. He was a distinguished engineer of broad interests and a great educator who, while he was continuing his engineering work, took the trouble to guide and encourage the younger engineers around him. The same words could be used to describe Doherty's industrial career. Although Lamme remained with industry, he was none the less an educator; and although Doherty has become a college president, he is none the less a distinguished engineer.

I once said to "Bob" Doherty that it would be very nice to be a farmer. He said "No, I know all about it. I was brought up on a farm." Later he worked in his father's drug store in his native town of Clay City, Ill.; and still later he worked for two years as a telegrapher.

He took a great interest in music and made an intensive study of musical composition. Generally books on artistic subjects consist of a great many unrelated "don'ts," with very few constructive, positive, general principles. "Bob" Doherty constructed for himself half a dozen general principles, and wrote a piece for the band in his home town. Unfortunately, he did not realize in the beginning that music for certain band instruments is written in one key and played in another; consequently, the first time the band tried to practice his piece the effect was horrible. After these technical difficulties were corrected, however, the band was so pleased that it used Doherty's composition as a special exhibition piece all one summer.

A Definite Goal

At college he was active in undergraduate affairs as well as in the classroom, serving on various committees and playing in the college band. Evidence of his proficiency and standing as a student is attested by his election to membership in Tau Beta Pi, Eta Kappa Nu, and Sigma Xi. After he was graduated from the University of Illinois with the degree of bachelor of science in electrical engineering in 1909 he entered the students' training course at the Schenectady works of the General Electric Company in the same year, and after two years in the testing department, joined the a-c engineering department as a designing engineer.

Doherty is one of the few men I know who has always had a definite goal and has stuck to it. His goal was two-fold: He wanted to do engineering work and he wanted to teach. Fortunately, these two goals are not incompatible.

He had a passion for understanding thoroughly what he was doing; and when he found that some of the designers around him were using formulas which they really did not understand, he decided that regardless of the pressure of work he would spend the first hour every morning, in addition to his evenings, in fundamental studies. As a result, he not only came to understand the bases for all the formulas then in use, but also he improved them and developed a great many new ones. This consulting-engineering work became so valuable that he was relieved of most routine work and gradually collected under him a group of young men doing pioneer work. His section became so well known in the company that in addition to work for his own department, he was consulted by many other departments....

One of his ambitions at the time he left college was to work for Doctor Steinmetz, and in 1920 he was transferred to the engineering general department, where he became Steinmetz's right-hand assistant and began to build up a small section doing general consulting work for the whole company.

During the time he worked with Doctor Steinmetz he took postgraduate work at Union College, receiving the degree of master of science in 1921. In 1922 he was given the title of consulting engineer. In that position his work was principally general consultation on engineering problems. The largest projects related to power transmission and to the behavior of electrical machinery under abnormal conditions.

Doherty's Scientific Stature

His technical papers presented before the Institute cover a wide range of subjects. Starting with the Doherty and Shirley paper on synchronous-machine reactance in

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An address delivered on the occasion of the presentation of the Lamme Medal for 1937 to Doctor Doherty, at the AIEE summer convention, Washington, D. C., June 21, 1938.

A. R. STEVENSON, JR., a former associate of Doctor Doherty, was graduated from Princeton University with the degree of civil engineer in 1914. In 1915 he received the degree of master of science in electrical engineering at Union College, and two years later the same institution granted him the degree of doctor of philosophy. Following his graduation in 1917 he served for two years in the Air Corps of the United States Army during the World War, then joined the General Electric Company. In 1923 he was appointed to the staff of the vice-president in charge of engineering, and now holds the position of assistant to the vice-president.

1. For all numbered references, see list at end of article.

1918 and going through the classic Doherty and Nickle series of papers on synchronous-machine performance during 1926–30, he, with his associates, built up a theory of salient-pole machines that promises to remain authoritative for many years to come. In this field alone his contributions and leadership entitle him to rank in the forefront of the engineering profession.

While he was carrying a heavy load at the office he had time to serve efficiently on the school board, and for one year was mayor of the village of Scotia, where he lived, and where again he demonstrated his ability as a leader. His qualities of leadership are evident throughout his scientific work. In each instance he had the vision and initiative to plan the project and the persistence to see that it was finished, but he gave his associates and students the opportunity of sharing the creative work and always was the first to give them credit and praise their ability. For instance, in commenting on the series of five papers which he and Nickle wrote, he always says, "Most of the work in the last three papers of the series was primarily due to Nickle." I know, however, how much time he devoted to this work with Nickle.

Some of his scientific contributions can be outlined further, the joint authorship of most of these papers indicating the team work which was developed under Doherty's leadership.

Doctor Doherty

Papers on Reactance

Before 1918 fundamental theory and data were reasonably adequate for the calculation of operating characteristics of machines with cylindrical rotors. The application of the existing theories and data to salient-pole machines led to trouble in the form of excessive oscillations and of undesirable division of load on synchronous frequency converters. Steinmetz and others already had made theoretical progress based on Blondel's fundamental conception of resolving the space distribution of the fields about the two axes of symmetry. This preliminary theory could not be applied satisfactorily, however, because it involved characteristic coefficients which at that time were not being determined rationally from design-sheet data. Doherty developed a method of determining these fundamental coefficients quantitatively from graphical flux plots based upon design-sheet data using the already existing theories of flux plotting.

This determination not only made possible the calculation of the much-needed "quadrature-axis synchronous reactance," thus rendering available the equation for the flux distribution over the armature surface; but also it made possible the rational determination of other design constants. More important, it cleared the way for further extensions of fundamental theory.

In this early work Doherty was assisted by Henningsen, Shirley, and Wieseman. The first public reference to the method was in the 1918 AIEE paper "Reactance of Synchronous Machines and Its Applications,"[1] by Doherty and Shirley.

The theory was developed further by associates and students of Doherty and presented in a series of three AIEE papers at the winter convention in 1927, under the general heading "Graphical Determination of Magnetic Fields,"[2–4] by Stevenson, Park, Johnson, Greene, and Wieseman.

Meanwhile, at the summer convention in 1926 Doherty and Nickle presented the first of a series of five papers setting forth the newly developed theory for salient-pole machines under the heading "An Extension of Blondel's Two-Reaction Theory."[5] Later important generalizations and refinements were made by R. H. Park,[6] an associate of Doherty, and were presented to the AIEE in 1928 and 1929.

Flux plotting is of great importance and has been intensively studied by others,[7–11] notably Lehmann in France. Doherty's real contribution was its adaptation to the solution of practical problems which had previously baffled designers.

The Constant-Linkage Theorem

When Doherty was a student engineer testing transformers at Pittsfield he had an experience that impressed forcibly on his mind the fact that there is a certain inertia or resistance to change involved in an interlinkage of magnetic flux and windings. While he was measuring the resistance of one winding of a large power transformer by the voltage-current method, Doherty short-circuited the other winding just prior to opening the power circuit. This was for the purpose of minimizing the arc and the induced voltage. After disconnecting the d-c power circuit, he descended the ladder upon which he had been standing, picked up a tool he had dropped, ascended the ladder, and then opened the short-circuited winding. Much to his surprise and subsequent delight, a large arc was drawn. He had learned, in a not-to-be-forgotten way, the meaning of the term "time constant."

Doherty first stated the constant-linkage theorem incidentally in the 1918 paper already mentioned, and formally presented proof in 1923 under the title "A Simplified Method of Analyzing Short-Circuit Problems."[12] This made easily possible the visualization and calculation of short-circuit phenomena which before had been regarded as of complex nature, and provided an additional block in the foundation on which the later extensions of theory were built.

The use of flux plots in determining characteristic constants of synchronous machines from design data and the constant-linkage theorem are the foundation of all the succeeding work in theory. If these two initial steps were taken out, the foundation would be missing.

Short Circuits on Induction Machines

One direct result of the constant-linkage theorem was Doherty's demonstration that, quite contrary to the gen-

eral belief of leading engineers, the initial short-circuit current of an induction generator was of the same order of magnitude as that of a synchronous machine of the same size. Commercial propositions were being prepared in 1919 on large induction generators on the grounds that they would not add to the initial short-circuit current of the system. Doherty and E. T. Williamson presented a paper at the AIEE winter convention in 1921 on "Short Circuit Current of Induction Motors and Generators,"[13] which changed the existing point of view and explained certain puzzling transient phenomena in such machines.

Exciter Instability

Complaints of loss or reversal of excitation on large a-c generators led to this investigation. Doherty showed that the equation for the excitation current of the alternator field was of the same form as that for the current in a circuit containing inductance, capacitance, and resistance, and therefore the exciter armature current might involve transient oscillations. This was confirmed by experiment, and the results were presented in a paper "Exciter Instability,"[14] presented at the Seattle convention in 1922.

Flywheels

The paper presented by Doherty and Franklin before the winter convention of the American Society of Mechanical Engineers in 1920, "Design of Flywheels for Reciprocating Machinery Connected to Synchronous Generators of Motors"[15] did not introduce a complete new theory but adapted existing dormant theory to the solution of another problem that had baffled designers.

This paper was of great importance in furnishing the basis for calculating the proper flywheel effect for synchronous units coupled directly to reciprocating apparatus such as oil or gas engines and air or ammonia compressors, and led to papers by others on the same subject,[16–18] which further developed the theory and the usefulness of the method based on a co-operative study with the engine and compressor builders.

The foregoing concerns Doherty's contributions in laying a foundation for the solution of important, difficult, practical problems, and the further development and refinement of theory and methods by his associates and students, who were stimulated to these advances by association with Doherty.

Through his own experience and his contact with other young engineers, Doherty came to realize that additional education was necessary to bridge the gap between what was learned in college and the application of that and further knowledge to real engineering problems. There was a tendency for young men to give up the habit of study and forget the more technical things they had learned, when they got out of college and started on practical work. Consequently, when they finally reached an engineering department they tended to become simply "handbook" engineers instead of thinking from a fundamental, technical viewpoint.

In 1922, therefore, Doherty proposed that the company should have an advanced course in engineering. As a result of a review of the proposal with various department heads, it became evident that there was really a need for more engineers with a fundamental training that would enable them to think for themselves, and he was authorized to start the course. I was lucky enough to be selected by him as his assistant in founding this educational program. We started it in the fall of 1923, graduated the first one-year class in 1924, and the first three-year class in 1926. This course is described in "An Advanced Course in Engineering"[19] and further detail here is unnecessary.

Out of the hundreds of young college graduates usually employed each year by the company, approximately 30 are chosen for a one-year course in which the fundamentals of science and engineering are reviewed, the chief object being to teach the students to think for themselves, to recognize the common fundamental bases of all engineering and to enable them to apply this fundamental scientific thinking to the actual solution of practical engineering problems. After completion of this one-year course, about half the men are selected to go on with two additional years of advanced study—some in electrical design, some in thermodynamics, and some in high frequency and electronics. Since the beginning in 1923, 429 men have been graduated from the one-year course and 115 men have completed the three-year course. The majority of these men have stayed with the company and are widely scattered throughout all its departments including engineering, manufacturing, commercial, and patent. Some of them have left the company and are doing good work, particularly in teaching.

Anyone who has run an educational institution knows how inevitably this leads to personnel work. As more and more advanced-course men began to be placed around the various departments, Doctor Doherty began to take more and more interest in the personnel of the departments, and was finally placed in charge of the engineering personnel. During this assignment he initiated and devised a series of rating sheets and personally visited all the engineering departments to help the department heads rate their men.

In April 1931, he was appointed professor of electrical engineering at Yale. In November 1932 he became dean of the new school of engineering at Yale.

During the past few years his contributions to the literature of engineering education, through the Society for the Promotion of Engineering Education and the Institute, have brought him wide recognition as a leader in formulating a modern philosophy of education. He believes in training men to think for themselves, to search out and make use of facts, and to measure their achievements by the service rendered to society. Most important of all, he is finding new ways to accomplish these objectives, and with unexampled energy is pressing engineering education to renewed progress.

In March 1936, he became president of Carnegie Institute of Technology. In that year he received the honorary degree of doctor of laws from Tufts College and from the University of Pittsburgh.

Those of us who know Doctor Doherty best feel that the Carnegie Institute of Technology made a very wise choice.

He is an engineer and an educator with definite, forward-looking plans for the improvement of engineering education. He is a fine executive, capable of carrying out his plans, and he is an all-round man interested in cultural as well as engineering subjects. For instance, he is very much interested in painting and several of his paintings have been exhibited. It is a particular gratification to him that Carnegie Institute of Technology is not only an engineering school but also includes a college of fine arts.

Doherty has always taken a great interest in his associates and has helped them to advance by stimulation and by going out of his way to give them full credit and praise for their accomplishments. This ability to appreciate his fellows genuinely has warmed the hearts of all his friends. Wherever "Bob" Doherty has been he has left behind a devoted circle of close friends, who continue to long for his stimulating society.

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Transcontinental Telephone Lines

(*Continued from page 419*)

a check of the completed work indicated that 50 per cent of the spans had been adjusted to within one-quarter inch. Telescopes are used to help obtain these close sag adjustments, and a final check is made by oscillating the wires in a span and observing the periods at which they oscillate.

Pole Spacing and Insulators

Poles must be spaced uniformly in order that the transpositions may be most effective, and an occasional deviation of only 35 feet is the maximum permitted. Where it is impossible to locate poles within this limit, such as is the case at long-span crossings, special fixtures are suspended from steel cables at the proper points to permit making the transpositions.

New types of insulators on steel pins, each pair of which is electrically bonded, are used to improve the stability of the transmission characteristics.

Wire 165 mils in diameter was used on this construction west of Oklahoma City because of its strength and resultant relative freedom from interruptions. Transmission losses were also a factor in this case. Rolled sleeve joints were used in splicing the wire because of their strength and good electrical characteristics. Flat tie wires, shown in figure 4, were used to reduce chafing of the line wire when the wires vibrate. Tie wires are not used at transposition points, as may be seen in figure 3.

Repeater Stations

The computed losses on open-wire pairs of this type at high-carrier frequencies and under different weather conditions are shown by figure 5. Field tests confirm these data. To offset the line losses it will be necessary to locate repeater stations at intervals of from 50 to 100 miles, depending upon the weather conditions which may be expected. Between Oklahoma City and Whitewater, Calif., in order to operate the 12-channel carrier telephone systems, it will be necessary to equip 16 intermediate repeater stations. Most of these will be unattended and maintained from other offices.

It is not practicable, of course, to bring the open-wire pairs directly into all repeater stations and in some cases entrance cables several miles long must be used. Although ordinary nonloaded cable pairs may be used for this purpose, their usage involves transmission difficulties, and except where other factors dictate the use of this type of facility, it is planned to use low-loss cable conductors of a new design. These cable pairs have more favorable impedance characteristics as well as lower losses.

With the building and the further equipping of this latest open-wire line across the western states, open-wire facilities have played one more important part in the development of long-distance telephony. Although cable is being found more and more useful, there still remain many important links in the nation-wide telephone communication network where, for the present at least, the open-wire line can serve best and the development of it toward maximum usefulness is still being carried on.

News

Of Institute and Related Activities

International Committees Consider Agreement on Electrical Problems

To CARRY international standardization agreements another step forward, 400 delegates from 22 countries met at Torquay, England, June 22–July 1 for the ninth plenary meeting of the International Electrotechnical Commission; 22 delegates from the United States attended the nine-day meeting.

Besides several important final agreements—notably one to co-ordinate the methods of rating transformers in different countries by showing both the test rating and the service rating on the name plate, and an agreement covering the properties of aluminum for use as electrical conductors—many of the IEC committees made progress in their work. Welding was added to the IEC program for the first time, the committee on welding holding its organization meeting at Torquay.

After nearly 25 years of work on an international dictionary of electrical terms, the new "vocabulary" of nearly 2,000 definitions in both French and English, was approved finally for publication. A preliminary summary of some of the actions taken at the Torquay meeting follows.

International Electrotechnical Vocabulary. The first edition of the vocabulary, containing some 2,000 scientific and technical terms defined in both French and English, and with titles in German, Spanish, Italian, and Esperanto, was approved for publication. Copies will be sent to those interested. Comments received by these committees will be considered by the IEC in revising the vocabulary.

Transformers. Two divergent methods of rating transformers have been in general use in different countries: one based on the full-load secondary current and the no-load secondary voltage; and the other based on the full-load secondary current and the full-load secondary voltage at a specified power factor of 0.8 or 0.85. The IEC delegates at Torquay agreed that both the IEC test rating and the IEC service rating should be shown on the name plate. It was agreed also that if no power factor is specified by the purchaser the service rating will be based on a power factor of 0.8, and that losses should be expressed in kilowatts and not as a percentage efficiency. Fractional loads are to be expressed in terms of current. The test rating agreed upon by the IEC as one of the factors to be used in rating transformers defines a transformer in which it might be desired to reverse the direction of flow of power. The service rating defines a transformer with a predetermined direction of flow.

Ambient temperature was defined to mean that the peak value of 40 degrees centigrade should be associated with an average temperature not exceeding 35 degrees centigrade over any 24-hour period. The maximum temperature rise for oil-immersed transformers with forced oil circulation, it was agreed, should be 65 degrees centigrade.

Graphical Symbols. Proposed revisions of the IEC graphical symbols were considered. It was suggested that the national committees submit proposals for additional sections on electronic devices (rectifiers), time switches, and clocks.

Lamp Caps and Holders. Dimensions of lamp caps and holders, approved by this committee, will be published by the IEC. Drawings of gauges were approved, but each national committee will decide for itself what gauges shall be used for checking the dimensions.

Aluminum. It was unanimously agreed that annealed aluminum should be defined as aluminum which, in the form of a wire having a diameter of one millimeter or more, has a maximum tensile strength of 9.5 kilograms, and a minimum elongation of 20 per cent in a length of 200 millimeters. The measurement of the elongation is to be taken after fracture. The normal resistivity value should be 0.0278 ohm for a cross-sectional area of one square millimeter and a length of one meter at a temperature of 20 degrees centigrade. The temperature coefficient and density for hard-drawn aluminum are considered to be the same as for annealed aluminum. For the steel core it was agreed to adopt a tensile strength of 120 kilograms per square millimeter of cross section and an elongation of five per cent for wires having diameters of three millimeters or more, and four per cent for wires having diameters smaller than three millimeters. Standards of resistivity for aluminum used for insulated cables and bus bars were agreed upon.

Standard Voltages and High-Voltage Insulators. A column showing the voltages per phase corresponding to the phase-to-neutral voltages for a three-phase system will be included in the new edition of the IEC publication on standard voltages, in the section between 100 and 1,000 volts. The first edition of an international specification on the testing of insulators will be issued. Impulse test voltages for the testing of line insulators will be included.

A draft specification for testing bushing insulators was referred to the national committees for consideration, together with a similar draft specification for bushings, and a report recommending revision of the IEC calibration tables for sphere gaps was approved.

Electric Traction Equipment. A revised edition of the specification for traction motors will be circulated to the national committees for approval.

Radio Communication. Draft specifications for capacitors as used in radio receivers devices for suppressing radio interference and a specification for symbols relating to electrodes and electrical magnitudes of electronic tubes were considered, but no action was taken. A revised draft of proposed safety regulations for mains-operated radio receivers is to be prepared.

Electrical Instruments. Revision of the publications on a-c watt-hour meters, instrument transformers, and indicating instruments was discussed, and joint action will be taken later. This committee held a joint meeting with the advisory committee on terminal markings, and the two committees appointed a subcommittee to consider marking instrument transformers separately from instruments and meters.

Shellac. A report on progress in application of shellac in the electrical industry during the past three years was presented by the chairman, A. J. Gibson, of Great Britain.

Terminal Markings. A report by this committee summarized the systems of terminal markings now in use, as follows:

1. The system used in the United States as given in the American Standard for Rotation, Connections, and Terminal Markings for Electric Power Apparatus
2. The system used in Great Britain, which will be available soon as a report of the British Standards Institution
3. A composite system taking certain of its parts from the systems of the different nations on the continent of Europe, the composite being consummated in discussions of IEC advisory committee number 16

It is expected that the IEC now will print the composite system as a report, in the hope that as the various nations find a change in their existing systems necessary, they will be able to adopt this system in its entirety, or in part.

Electric and Magnetic Magnitudes and Units. The committee agreed to recommend that the connecting link between the electrical and mechanical units should be the permeability of free space (μ_0) with the value of 10^{-7} in the unrationalized system. The committee agreed also to recommend that the name of the unit of force be the "newton."

ASME Committee on Rubber and Plastics. A committee on rubber and plastics has been established by the American Society of Mechanical Engineers to deal with several phases of the rubber and plastics industries including mechanical application, research on basic mechanical properties, processing equipment, and standards. As one of its early activities, the committee will sponsor a symposium on rubber at the next meeting of the society to be held October 5–7, 1938, at Providence, R. I.

Southern District Meeting Offers Attractive Features

Plans for the AIEE Southern District meeting, to be held in Miami, Fla., November 28–30, 1938, now are practically complete. The program includes many papers of interest to the membership of the Institute, and the exceptional sport and recreational facilities available in Miami will provide abundant amusement for the guests and their families.

The program, as outlined, will consist of registration and opening of the meeting on the morning of Monday, November 28. The afternoon and evening of the opening day will be devoted to student activities under Professor E. F. Smith, as chairman, and will be followed by a student and counselor's dinner. Technical sessions Tuesday morning will be on transmission and distribution followed that afternoon by papers on education, economic, and sociological subjects. The technical session Wednesday morning will be devoted to papers on electrical generation and equipment. Wednesday afternoon will be devoted to special committee meetings, inspection trips, and recreation.

Many unusual opportunities exist for a variety of sports and recreation. The entire facilities of the Miami Biltmore Hotel and Country Club, which include its championship 18-hole golf course, fast clay tennis courts, and fresh water swimming pool will be at the disposal of members and guests. Available also will be the Roney Plaza Cabanas with a salt-water pool and private bathing beach, as well as the Key Largo Anglers Club Camp. These recreational facilities provide the best of equipment for golf, tennis, and bathing, as well as some of the finest salt water fishing which can be found in the United States.

Completion of the Overseas Highway, which joins Miami and Key West with a modern hard-surfaced automobile road, provides an interesting structural study for engineers, and a beautiful and colorful trip for those who travel it. Arrangements have been made which will enable those attending the meeting to take a trip to Cuba at nominal expense.

It is hoped that the members of the Southern District and others will plan to combine their attendance at the meeting with a vacation trip in order that they will have ample time to enjoy the many pleasures available to the visitors.

Details of the program will be announced in the November issue.

The personnel of the Southern District meeting committee is as follows: A. P. Michaels, chairman; E. D. Wood, vice-president, AIEE Southern District; A. S. Hoefflin, secretary, AIEE Southern District; E. E. George; E. F. Johnson; M. E. Lake; E. F. Smith; W. Austin Smith; and Joseph Weil. The chairmen of the subcommittees are as follows: J. C. Jones, *papers and program;* J. B. Hiers, Jr., *finance;* J. D. Preston, *attendance and publicity;* P. J. Carlin, *transportation;* R. Y. Pool, *entertainment;* and E. F. Johnson, *hotel and reservations.*

A View of the Seven Mile Bridge from Pidgeon Key, part of the Miami-Key West Overseas Highway

Symposium on Apparatus Rating Proposed for Winter Convention

FOLLOWING recent discussions in the standards and electrical machinery committees of the AIEE, the chairman of the latter committee has appointed a subcommittee, of which F. E. Harrell is chairman, to study the general questions of temperature limits and rating of small power apparatus. This committee has decided to sponsor a symposium on this subject which is proposed for the forthcoming winter convention in January 1939. Tentative arrangements have been made for the inclusion of this symposium on the program, subject of course to the approval of the papers submitted, with a full opportunity for discussion.

It is planned in this symposium to consider three general aspects of the rating problem: the temperature limits of insulating materials; the methods of determining hot-spot temperatures in machines; and the general principles of rating. The object of the symposium is primarily to formulate suggestions for revision and extension of the standards on general-purpose motors and similar small apparatus, especially with class *A* insulation. It is not proposed to discuss on this occasion the problems of rating of large or high-voltage apparatus, in which distinctly different insulating materials are used, and to which different operating conditions apply.

The general principles on which present temperature limits, in the rating of electrical apparatus, are based are given in AIEE Standards No. 1, prepared in 1925. These standards establish a continuous hot-spot temperature limit of 105 degrees centigrade for class *A* insulation and provide for a conventional allowance of 15 degrees centigrade between the temperature as measured by thermometer and the hottest spot. They also establish 40 degrees centigrade as the standard ambient temperature in determining the limiting temperature rise in apparatus rating.

In the past 15 years, many developments have occurred which suggest the need of reviewing this basic standard. Much new information has been accumulated on the life of insulating materials under different temperatures, and new materials have been developed not considered in the old standards. The committee, therefore, proposes to have one group of papers presented dealing with the new information on temperature endurance of various insulating materials now used or proposed for future use in small power apparatus. Plans as so far developed include a paper on the temperature-life characteristics of class *A* insulations, another paper on developments in glass insulation, and a third on the properties of magnet wire.

A second group of papers will deal with the question of hot-spot-temperature determination, and, in general, methods of specifying temperature limitations. One paper has so far been promised, dealing with temperature rise determination of induction motors, and other contributions are planned. A question at issue here is the extent to which resistance, instead of thermometer or thermocouple methods of measurement, should be used in determining motor temperatures. The recent trend toward the use of fan-cooled and enclosed motors of many types has made it increasingly difficult to get accurate thermometer readings of hot-spot temperature rise. On the other hand, the use of resistance measurements exclusively gives an average, rather than a maximum, temperature value and introduces new problems in the way of

simple and accurate measuring apparatus. It is hoped that discussion at the meeting will bring out new information on this important subject.

The third group of papers will deal with the general principles of rating of apparatus, including permissible overload limits under different duty cycles and different ambient temperatures. The philosophy of rating, as developed over the past 15 years, leads more and more to the complete separation of operating from rating standards. Rating standards are necessary to give definitely determinable and comparable conditions of performance. Apparatus with this single standard of rating, however, must be used under widely different conditions of loading, depending on ambient temperatures, operating conditions, and the desired economic life of the equipment.

Recognizing these considerations the new American standards for transformers, shortly to be published, will include recommendations for the operation of small transformers in accordance with temperature under various intermittent conditions of loading. The standards will permit short-time overload operation of transformers on a graduated basis, determined so as to give the same total insulation life of the transformer in years under all conditions. The recent developments in automatic duty cycles and short-time overloads for motors in air-conditioning, refrigeration, and many other household and industrial applications, indicate the need for corresponding revision of the American standards on motors.

The committee has so far planned to include four papers in the symposium on this aspect of the subject, one on the rating of general-purpose induction motors, another on the application of motors in the refrigeration industry, a third on rating principles in general, and a fourth on the experiences of the transformer committee, on which the new standards are based.

The committee invites suggestions in regard to additional papers and subjects to be considered. All communications should be addressed to: F. E. Harrell, chairman, AIEE subcommittee on rating of electrical machinery and apparatus, care of The Reliance Electric and Engineering Company, 1068–1088 Ivanhoe Road, Cleveland, Ohio.

Future AIEE Meetings

Southern District Meeting
Miami, Fla., November 28–30, 1938

Winter Convention
New York, N. Y., January 23–27, 1939

South West District Meeting
Houston, Texas, Spring, 1939

North Eastern District Meeting
Springfield, Mass., May 1939

Summer and Pacific Coast Convention (combined)
San Francisco, Calif., June 26–30, 1939

Middle Eastern District Meeting
Scranton, Pa., October 11–13, 1939

Great Lakes District Meeting
Minneapolis, Minn., Fall, 1939

Chemistry Subcommittee of NRC Insulation Committee Meets at Milwaukee

FOR THE third successive year the attention of chemists meeting in national assembly has been directed toward the problems of electrical insulation. In each instance the discussion of dielectric phenomena has been held under the joint auspices of the American Chemical Society and the subcommittee on chemistry of the committee on insulation of the National Research Council, division of industrial and engineering research. The 1938 conference was held at Milwaukee, Wis., September 8, most important business of which was a symposium under the chairmanship of Doctor F. L. Miller, of the Esso Laboratories, Standard Oil Development Company, Linden, N. J. This report has been made available to readers of ELECTRICAL ENGINEERING through the courtesy of Doctor F. M. Clark (A'24), General Electric Company, Pittsfield, Mass.

At the symposium, which was attended by approximately 125 chemists and engineers, four papers were presented and discussed:

1. LIQUID DIELECTRICS—SOME CHEMICAL, PHYSICAL, AND ELECTRICAL PROPERTIES OF SYSTEMS CONTAINING LEAD OR COPPER SOAPS IN LIQUID PARAFFIN, **John D. Piper, A. G. Fleiger, C. C. Smith** (A'29), and **N. A. Kerstein**, The Detroit Edison Company, Detroit, Mich.
2. A CRITICAL STUDY OF SOME TESTS USED IN THE INVESTIGATION OF INSULATING-OIL DETERIORATION, **J. C. Balsbaugh** (A'23, M'35) and **J. L. Onclay**, Massachusetts Institute of Technology, Cambridge.
3. CHEMICAL FACTORS INFLUENCING THE STABILITY OF MINERAL-OIL-TREATED INSULATION, **F. M. Clark** (A'24), General Electric Company, Pittsfield, Mass.
4. THE ELECTRICAL APPLICATION OF POLYSTYRENE, **L. A. Matheson** and **W. C. Goggin**, Dow Chemical Company, Midland, Mich.

During brief introductory remarks the members and guests were welcomed by Doctor H. S. Gardner, secretary of the division of industrial and engineering chemistry of the American Chemical Society, and by Doctor F. L. Miller, chairman of the subcommittee on chemistry of NRC. Doctor Miller referred to the highly interesting and profitable conferences of the past two years and acknowledged the real value that chemistry can contribute—and is contributing—to the solution of many complex problems in the use of dielectric materials. Doctor Miller thanked the American Chemical Society for its activity in sponsoring the symposium and for its valuable aid in bringing to the attention of chemists the varied and important problems on the chemical solution of which depends continued progress in the use of industrial dielectrics.

TECHNICAL SESSIONS

Liquid Dielectrics. J. D. Piper, in presenting the first paper, described a series of tests to determine which of the types of products that may be formed by the service degradation of insulating oils cause serious dielectric losses in oils at 60 cycles per second, and which do not. "Properties of systems composed of liquid paraffin and a cupric or lead soap of the following acids have been investigated: 1,10-hydroxystearic, stearic, palmitic, myristic, lauric, capric, pelargonic, caprylic, cyclohexanecarboxylic, undecylenic, erucic, and abietic acids. In the preparation of these soaps, some of which were crystalline, possible adsorption of alkali ions was avoided by treating the acetates with the above acids rather than with their alkali soaps.

"The systems containing cupric soaps of individual acids had low power factors and conductivities at all temperatures including those near which the soaps separated from solution. Systems containing mixed soaps, prepared from cupric abietate and certain acids or other soaps, however, had high power factors and high conductivities and dielectric constants at certain temperatures. . . . The dielectric properties of the systems are believed to be related to the state of dispersion of the soaps in the oil."

Insulating-Oil Deterioration. This paper, presented by J. L. Onclay, described investigations being conducted at Massachusetts Institute of Technology under the general direction of the committee on insulating oils and cable saturants of Utilities Co-ordinated Research, Inc. After an exhaustive presentation of the problem and its analysis, Doctor Onclay summarized the results as follows:

1. The relative proportions of various oxidation products and the rates of oxidation of hydrocarbons of various types vary over a rather large range.
2. The Grignard test is a very valuable tool, and reveals both the total oxidation products and the active hydrogen in an oil.
3. The synthetic hydrocarbons studied in this work had much lower dielectric losses for a given amount of chemical deterioration than did the group of oils studied.
4. Studies of the d-c conductivity, and of the power factor and dielectric constant over the frequency range from 40 to 400 cycles per second show that the dielectric losses are due almost entirely to ionic conduction.
5. Oils having an unusually large ratio of dielectric constant to density are usually found to exhibit a rapid rate of deterioration when subjected to oxidation.
6. Light transmission measurements over the entire visible portion of the spectrum are reported in the hope that such a study may reveal the nature of certain deterioration products.
7. The significance of volatile deterioration products is discussed from the viewpoint of their behavior in an oil-impregnated cable.

Mineral-Oil-Treated Insulation. Emphasizing that fundamental studies of insulating materials apart from the commercial product are of real value, Doctor Clark pointed out that such materials nevertheless are seldom used alone, and that the successful use of dielectrics in industrial service demands careful evaluation of the behavior of the composite assembly. Especially important are the deterioration products formed under high-voltage stresses in the presence of air at the higher operating temperatures, together with the dispersion of such products in—and on—the cellulosic insulation present. Doctor Clark's conclusions were summarized as follows:

1. The suitability of oil-treated cellulosic insulation for high-voltage application is determined

largely by the ability of the insulating mineral oil to resist the destructive effects of ionization and chemical oxidation.

2. The dielectric stability of mineral-oil-treated insulation is greatly influenced by the susceptibility of the mineral oil to oxidation. The beaker oxidation test, however, is not a proper gauge of the suitability of mineral oil for impregnation. Such tests fail to give data concerning the reactivity of the oxidation-formed products. The effect of high voltage stress on their formation and their ability to disperse through the cellulosic insulation and to be absorbed by it.

3. The ability of oil-treated cellulosic insulation to resist dangerous oxidation effects is best determined by an examination of the power factor of the treated paper as affected by a voltage life test. A suggested test is carried out at 75 degrees centigrade, the surface of the impregnating oil in which the test specimen is immersed being exposed to air.

4. To obtain the highest degree of dielectric stability in Gulf Coast mineral-oil-treated cellulosic insulation, the impregnating oil should contain a minimum of olefinic, unsaturated, oil-soluble compounds and a restricted amount of aromatic, unsaturated compounds of the type normally present in crude oil. For the Gulf Coast type of mineral oil the optimum amount of aromatic, unsaturated compounds should be between approximately four and five per cent.

5. Oil-soluble contaminants in the mineral oil may produce abnormally high initial power-factor values for the treated insulation. Equally dangerous effects are produced by those oil-soluble contaminants which have little effect on the initial power factor, but which contribute to insulation instability during the high-voltage use of the treated dielectric. Such a material is stearic acid.

6. Completely saturated paraffin hydrocarbon mixtures are not suitable for high-voltage dielectric use.

7. The addition of pure aromatic hydrocarbons of the benzenoid type to minerals in order to reduce gas evolution under electric discharge is limited by the effect of such materials on the dielectric stability of the treated insulation. Paraffinic carbon chains in the molecule of the aromatic addition must be avoided.

Electrical Application of Polystyrene. This paper, presented by L. A. Matheson, constituted an analysis of the properties of polystyrene. This substance, a transparent, thermoplastic solid, is formed by the polymerization of monomeric styrene, a colorless liquid having a boiling point of 146 degrees centigrade. Polystyrene has a low power factor (about 0.01 or 0.02 per cent) low water absorption, and low dielectric constant (from 2.6 to 2.8). "The low power factor and low water absorption seem to arise from the lack of polarity and the strong binding of all components in the chain. The polymer consists of only carbon and hydrogen atoms, the majority of which are in the benzene ring structures. Polystyrene is transparent and exhibits a tensile strength of from 5,000 to 7,000 pounds per square inch." It has a good modulus of elasticity and hardness and a fair impact strength. The maintenance of the impact strength at low temperatures is noteworthy. Operations which stretch the polymer during cooling are applied to increase the impact strength and the elongation before tensile break. Plasticizers may be added to increase the elongation and pliability.

The excellent dielectric properties and low water absorption promise a wide use for polystyrene in the electrical industry. Among the uses suggested for polystyrene are (1) cast pieces to be used where high resistance, transparency, and excellent electrical and mechanical properties are demanded; (2) high-voltage cable joints; (3) molded articles; and (4) films for cable and capacitor insulation.

The paper includes detailed data covering the properties of polystyrene; these are important in the proper application of the material for the uses suggested.

Dinner Meeting

Following the symposium was a "get together" dinner, at which F. M. Clark delivered an address on "A Chemical Approach to the Problem of High-Voltage Dielectrics."

As a result of the success of this symposium and its predecessors, the subcommittee on chemistry of NRC plans to schedule similar conferences each year under the auspices of other divisions of the American Chemical Society, in such fields as rubber, paint and varnish, cellulose, and plastics.

Membership—

Mr. Institute Member:

National and Section activities are now beginning for this season. You are urged to take full advantage of the many opportunities afforded you as a member to meet and join in discussions with your fellow engineers. Personal activity in these functions pays dividends.

Your membership committee is getting under way also. The assistance you have given the committee in the past has aided us greatly and is much appreciated. It is our hope that you will continue your fine co-operation.

With best wishes for a successful season.

L. L. Webb

Chairman, National Membership Committee

NRC Insulation Conference to Meet in Pittsburgh

The eleventh annual meeting of the conference on electrical insulation of the division of engineering and industrial research, National Research Council, will be held in Pittsburgh, Pa., November 3–4, 1938, where the conference will be the guests of the Westinghouse Electric and Manufacturing Company, the Gulf Research and Development Company, and the Mellon Institute of Industrial Research. Features of the meeting will comprise three technical sessions, a varied program of visits to many plants of scientific and industrial interest in the neighborhood, and the annual dinner of the conference.

In the technical sessions a program of unusual interest will be presented covering reports of recent progress in the scientific, the technical, and the practical aspects of dielectrics as applied to the problems of insulation. Progress reports will be presented from the National Bureau of Standards, several industrial research laboratories, and from a number of university laboratories. The tentative program, as at present arranged, comprises 24 papers. As is usual, the annual dinner on November 3, will be followed by a lecture. The speaker this year will be Doctor E. U. Condon, of the Westinghouse laboratories.

The headquarters for the meeting will be the Schenley Hotel. The chairman of the conference is Doctor J. B. Whitehead (A'00, F'12) of The Johns Hopkins University; the chairman of the local committee is Doctor C. F. Hill (M'29) of the Westinghouse Electric & Manufacturing Company.

Largest Generator Since 1931 Purchased. Niagara Hudson Power Corporation recently announced the purchase of the largest turbogenerator to be acquired by an electric utility company since 1931. The new equipment will be erected in a new station at Oswego, N. Y., construction of which is to be started soon by Central New York Power Corporation, a subsidiary of Niagara Hudson. Rated at 80,000 kw, 13,800 volts, 1,800 rpm, the generator will be cooled by hydrogen. The turbine, which will operate at an input steam pressure of 1,250 pounds per square inch and a temperature of 900 degrees Fahrenheit, exhausting into a vacuum of about one inch of mercury, is said to be the first high-pressure condensing unit to be built in a single casing. Length of the turbine will be slightly more than 53 feet over-all; its height above the floor is to be about 13 feet; and it will weigh approximately 500 tons. This unit is to be constructed by the General Electric Company, and is expected to be completed in about 14 months.

Electricity to Play Vital Role at the 1939 New York and San Francisco Fairs

ELECTRICITY will play a dominant role in the 1939 expositions of both East and West—the New York World's Fair to be held in New York City, and the Golden Gate International Exposition to be held in San Francisco, Calif. Not only will electricity be featured in special exhibit buildings at both fairs, but also it will play an almost indispensable part in staging the expositions and in lighting them. Special distribution systems are being constructed to supply the electric energy needed.

The New York fair will open April 30, 1939, the 150th anniversary of the inauguration of George Washington, which took place in New York City. It will be held on a site embracing 1,216 acres in Flushing Meadow Park situated in Queens, most easterly of the city's five boroughs. Its underlying theme is "building the world of tomorrow"; its estimated cost will be \$150,000,000. After the fair is over, the site will be used as a city park and some of the buildings, of permanent construction, will remain.

The Golden Gate exposition commemorates the completion of San Francisco's two great bridges, the San Francisco-Oakland Bay Bridge and the Golden Gate Bridge; it will open February 18, 1939, and its estimated cost will be \$50,000,000. The site of the exposition is a 400-acre man-made island in San Francisco Bay adjoining Yerba Buena Island and between the two bridges; there will be a highway connection with the bay bridge. After the fair is over, the island will be cleared of all buildings except the permanent administration building and two large hangars, and will become an airport.

Dominant structures in the New York fair will be a 200-foot "perisphere" and a 700-foot "trylon," both of which are interesting from an engineering point of view. The sphere will contain the theme exhibit of the fair, which will be observed from a moving platform around the inner periphery. The trylon is a slender triangular pyramid about 64 feet on a side at the base. A total of 6,710,000 pounds of steel comprising 7,125 pieces have been used in erecting the framework of these structures. Both will be covered with a white magnesite composition similar to stucco. As its dominating structure, the Golden Gate exposition will have its 400-foot Tower of the Sun. This tower will be topped by a 22-foot statue of a phoenix, covered with gold leaf.

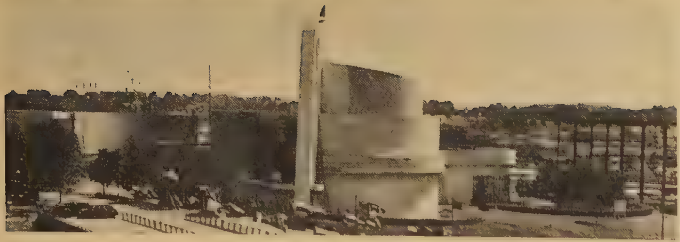
Electrical exhibits at the Golden Gate exposition will center in the Palace of Electricity and Communication, while the New York fair will have its Electrical Building and private exhibit buildings to be erected by electrical manufacturers and utilities. Communications exhibits will be housed in a separate building at the New York fair and in buildings to be erected by some of the major communication systems. Electrical exhibits at both fairs will emphasize the contributions of electricity to modern living and will attempt to predict how electricity may contribute in the future. Both fairs will have "electric farms." Of particular interest among the exhibits at the New York fair will be a lightning laboratory capable of producing 30-foot arcs which may be observed by visitors. Among the interesting communication features at the Golden Gate fair will be a radiobroadcasting center. Both fairs will have television demonstrations.

Perhaps electricity's greatest contribution to both fairs will be the provision of illumination. Of particular significance is the fact that both expositions will be considered as co-ordinated units from the standpoint of both color and illumination. Electrical illumination of all types will "paint" the fairs at night. Of especial interest will be the wide application of fluorescent lighting to be provided chiefly by the new gaseous tube fluorescent lamps (*EE, June '38, p. 245–8; July '38, p. 286–90*). At the San Francisco fair fluorescent paint will be used on some of the murals which will be activated by ultraviolet radiation or so-called "black light" (*EE, Dec.' 37, p. 1449*). At the New York fair, trees in some of the areas will be irradiated with ultraviolet radiation, which will cause the leaves to fluoresce. Luminaires of unique designs will be found in abundance at both expositions. Interior illumination also will be unique.

In addition to the strictly electrical displays and the illumination, many other exhibits will be of interest to electrical engineers, particularly the transportation, science, and chemical exhibits. All types of transportation will be featured, and at the New York fair the building erected by the Eastern Railway Presidents Conference will be the largest on the grounds. San Francisco will have a special demonstration featuring electricity in business, and a model cyclotron or "atom smasher" designed to produce radioactive emanations for the treatment of cancer and other diseases.

Among the spectacular displays of special interest at the fairs will be a reproduction of the geyser "Old Faithful" at San Francisco, which will erupt regularly with a 150-foot column of water illuminated at

A recent view of the New York World's Fair showing most of the exhibit area, taken on the day that the final rivet was driven in the theme-center structures. Part of the electrical building may be seen at the extreme right edge



Electrical building at the New York World's Fair. The building of the Consolidated Edison Company of New York, Inc., may be seen at the left and the steel frame of the Westinghouse Electric and Manufacturing Company building at the right

(Right) A recent view of the Golden Gate International Exposition showing the main entrance and part of the grounds. The electrical building is immediately to the left of the main entrance

night, and two "super" fountains at the New York fair. One of these displays will include water and flame synchronized with color effects and special music and sound. The other display, which is described as "the nearest approach to chaos that man can contrive for purposes of sheer entertainment," will combine all these elements and will include fireworks as well.

To provide the electric energy needed for the fairs, special distribution systems are being built. San Francisco will have a 16,000-kva substation supplied from the Oakland side of the bay over three submarine cables 9,000-feet long. Power will be distributed to various parts of the island by means of 4,000-volt underground feeders. New York's $2,000,000 distribution system will comprise two 45,000-kva substations fed by 27-kv feeders. Each substation will be supplied from two sources over different routes. Power will be distributed from these substations to various parts of the grounds by means of 4,150-volt feeders.

Of particular interest to those members who may plan to visit the Golden Gate exposition is the fact that the AIEE will hold a combined summer and Pacific Coast convention in San Francisco, June 26–30, 1939.

Transactions Supplement for 1938 to Be Issued

To enable members and subscribers to receive a complete file of the technical papers and related discussions not published in the TRANSACTIONS section of ELECTRICAL ENGINEERING under the present publication policy during 1938, a special "TRANSACTIONS Supplement" will be published in December, as announced in a special brochure recently mailed to all AIEE members. This supplement together with the 12 issues of ELECTRICAL ENGINEERING will provide *all* the technical papers and discussions published by the Institute during the year.

Normally under the present publication policy, the TRANSACTIONS Supplement would contain approximately 350 pages reprinted from the TRANSACTIONS, and the price to members would be $1.00 per copy postpaid. Because of the effects of this year's transition in publication procedure, however, the 1938 Supplement will contain only some 85 pages and will be available to members at 50¢ per copy postpaid. The Supplement will be paper bound similar to ELECTRICAL ENGINEERING.

Advance orders are required because the number of copies to be printed will be determined by the demand. Therefore, those wishing to receive copies should fill in the appropriate spaces on the return card accompanying the mailed announcement (or use the order form on page 18 of the advertising section of this issue) and forward it at once to AIEE Headquarters, 33 West 39th Street, New York, N. Y.

Industrial Research Institute Formed

The Industrial Research Institute, an organization of research executives affiliated principally with middle-sized and small industrial corporations, has been formed following a series of preliminary meetings at New York, N. Y., according to an announcement by Maurice Holland (A'23, M'30) director of National Research Council's division of engineering and industrial research, who is acting as executive officer of the new group.

Research men in various fields of industry had expressed a desire for an organization in which they could discuss laboratory organization and administration and other problems common to directors of scientific research. Representatives of 40 industrial corporations attended the first preliminary meeting in March 1938 when results of a survey among 500 research laboratories to determine the extent of the need of the organization were reported.

The executive committee of the new body will serve as a committee of NRC during the formative and development stages. R. P. Colgate, vice-president, Colgate-Palmolive-Peet Company, has been named chairman, and H. W. Graham, general metallurgist, Jones and Laughlin Steel Corporation, is vice-chairman. The NRC division of engineering and industrial research has made its facilities and technical resources available to the new research institute during the organization period; present headquarters are at the offices of the NRC division at 29 West 39th Street, New York, N. Y.

ICI Sessions in Holland. The next sessions of the International Commission on Illumination will be held in Holland June 12–21, 1939, according to advice just received from the Central Bureau in England. The meeting will be at Scheveningen, the seashore resort and suburb of The Hague where the International Electrotechnical Commission met in 1935.

17-Year AIEE Index Now Under Consideration

The issuance of a cumulative index to its technical papers for the 17-year period, 1922–38, currently is under consideration by the Institute, as announced in a special brochure recently mailed to all AIEE members. Such a volume would complete the series of indexes covering Institute papers from 1884 to date, but will be issued only if there is sufficient demand for it. As an added inducement, it is planned that a copy of the previous index volume, covering the years 1911–21, will be given free of charge to those ordering copies of the new index, until the present stock is exhausted.

Covering some 2,500 reports and technical papers by several hundred authors and technical committees, the proposed index would comprise a volume of 150 or more $8^1/_2$- by 11-inch pages containing some 15,000 reference entries alphabetically arranged. The style and arrangement of the index would be similar to the annual multi-entry indexes that have been published during recent years for TRANSACTIONS and ELECTRICAL ENGINEERING.

Although the project has been approved in principle by the board of directors, upon recommendation of the publication committee, budget provision will be made only if it receives sufficient support among Institute members and subscribers to Institute publications. The price of the proposed 17-year index to AIEE members will range from $1.25 upward, depending upon the quantity to be produced, but will be kept to a minimum. Those interested are

urged to fill in the appropriate spaces on the return card accompanying the mailed announcement (or use the order form on page 18 of the advertising section of this issue) and forward it at once to AIEE Headquarters, 33 West 39th Street, New York, N. Y.

Institute Publication Buried in Time Capsule

The seven-foot "time capsule," recently deposited 50 feet in the earth beneath the exhibit building of the Westinghouse Electric and Manufacturing Company on the grounds of the New York World's Fair 1939, contains a complete copy of the Institute's 50th anniversary (May 1934) issue of ELECTRICAL ENGINEERING reproduced on microfilm. The 800-pound "cupaloy" metal envelope is addressed to people living 5,000 years hence, and is intended to preserve for scientists of the year 6939 a tangible record of life in the present era. It contains representative fruits of the modern achievements in science and art, delineated by such things as news reels and

The time capsule itself is made of two parts: an inner "crypt" of heat-resistant glass surrounded by a corrosion-resisting copper-alloy shell

books reproduced on microfilm and selected subjects from laboratories, factories, and cities.

A single copy of the May 1934 issue of ELECTRICAL ENGINEERING is twelve inches long, nine inches wide, and about three-quarters inch thick. This represents a volume of 81 cubic inches, and obviously the time capsule could not accommodate enough of such books to provide an accurate literary cross section of this age. This was one reason for the use of microfilm in reproducing the buried documents. An entire book may be reproduced on a roll of microfilm that occupies a volume of only three or four cubic inches. But there was another reason; the material of which film base is made has been found to be more resistant to the ravages of time than even the finest of rag papers.

Egyptians had an excellent way of preserving mummies, and modern scientists always have been a little curious about how it was done. Assuming that the time capsule actually is found intact by some savant of the nebulous year 6939, he probably will marvel at the remarkable durability of the metallic shell surrounding the buried treasure. But Westinghouse engineers are not going to frustrate his curiosity as Egyptians have frustrated scientists of our day, for the time capsule contains the formula for the metallic material known as "cupaloy," an alloy of copper, chromium, and silver, of which the shell is made.

This metal is believed to have the physical and chemical durability necessary to insure its survival against the corroding action of sea water in the soil of the World's Fair grounds during the next five milleniums. Copper itself is resistant to corrosion of salt water, because the products of initial corrosion accumulate and protect the underlying metal. The presence of chromium in the alloy probably will increase the protective value of the film which would be expected to form under the influence of undisturbed soil corrosion. Confidence in the ability of the alloy to withstand the attack of time is strengthened by the evidence of many copper implements that have been preserved from antiquity. A further reason for the belief in the ability of the capsule to withstand corrosion is that in electrolytic reactions with corrosive salts, such as iron salts, copper becomes the positive electrode and therefore receives deposits instead of being eaten away in the process.

Inside the metallic shell of the capsule is a six-foot chamber made of heat-resistant glass, which contains the items representing a "cross section" of our time. This glass envelope was evacuated and filled with an inert gas to act as a preservative, then wrapped with glass tape and embedded in a waterproof compound.

Simultaneously with the deposit of the capsule, the leading libraries, museums, and repositories of the world will receive a finely bound and printed book, published on the most permanent paper, telling future archaeologists where the capsule lies, what is in it, and how to locate and recover it.

IES Elects Officers. During the 32d annual convention of the Illuminating Engineering Society, Milwaukee, Wis., August 29–September 1, 1938, the following new officers were elected: *president*, D. W. Atwater (A'34), Westinghouse Lamp Division, Bloomfield, N. J.; *vice-president* (term expires 1939), L. H. Grades, Curtis Lighting, Inc., New York, N. Y.; *vice-president* (term expires 1940), A. D. Cameron, Holophane Company, Inc., New York, N. Y.; *general secretary*, H. M. Sharp (M'34), Buffalo, Niagara, and Eastern Power Company, Buffalo, N. Y.; *treasurer*, H. G. Clum, Jersey Central Power and Light Company, Asbury Park, N. J. The 1939 annual convention of the society is scheduled to be held at San Francisco, Calif.

"Dams and Control Works," revised edition of a book first published in 1929, has been announced by the United States Bureau of Reclamation. Dams of various types, control works, and special engineering investigations of the bureau are described in detail; chapters are devoted to the design and construction of such outstanding structures as Boulder and Grand Coulee Dams, and special articles discuss such subjects as high-pressure reservoir outlets and temperature control of mass concrete in large dams. A tabular description of 138 dams built by the bureau and a general map of federal irrigation projects are included. The book may be obtained from the Bureau of Reclamation, Washington, D. C., at $1 a copy.

Future Meetings of Other Societies

American Association for the Advancement of Science. Winter meeting, December 27–31, Richmond, Va.

American Gas Association. October 10–14, Atlantic City, N. J.

American Institute of Mining and Metallurgical Engineers. Coal division (joint meeting with ASME and Western Society of Engineers), October 13–15, Chicago, Ill.

Industrial minerals division, October 20–21, Los Angeles, Calif.

American Physical Society. 223d meeting, November 25–26, Chicago, Ill.

224th meeting, December 1938, Los Angeles, Calif.

Annual meeting, December 26–28, Washington, D. C.

American Society of Civil Engineers. Fall meeting, October 12–14, Rochester, N. Y.

Annual meeting, January 18–20, New York, N. Y.

American Society of Heating and Ventilating Engineers. 1939 annual meeting, January 23–26, Pittsburgh, Pa.

American Society of Mechanical Engineers. Joint meeting with AWS, October 18, Detroit, Mich.

Annual meeting, December 5–9, New York, N. Y.

American Welding Society. 19th annual meeting and welding exposition, October 16–21, Detroit, Mich.

National Electrical Manufacturers Association. October 24–28, Chicago, Ill.

National Metal Congress. October 17–20, Detroit, Mich.

National Research Council, Highway Research Board. 18th annual meeting, November 20–December 2, Washington, D. C.

Society of Automotive Engineers. National transportation engineering meeting, November 14–16, New York, N. Y.

Annual meeting, January 9–13, Detroit, Mich.

Letters to the Editor

CONTRIBUTIONS to these columns are invited from Institute members and subscribers. They should be concise and may deal with technical papers, articles published in previous issues, or other subjects of some general interest and professional importance. ELECTRICAL ENGINEERING will endeavor to publish as many letters as possible, but of necessity reserves the right to publish them in whole or in part, or reject them entirely.

ALL letters submitted for consideration should be the original typewritten copy, double spaced. Any illustrations submitted should be in duplicate, one copy to be an inked drawing but without lettering, and other to be lettered. Captions should be furnished for all illustrations.

STATEMENTS in these letters are expressly understood to be made by the writers; publication here in no wise constitutes endorsement or recognition by the American Institute of Electrical Engineers.

Symmetrical-Component Impedance Notation

To the Editor:

No entirely adequate and consistent notation for impedances in symmetrical components has been presented in the books on symmetrical components nor has such a notation come into general use. In particular, the symbols Z_0, Z_1, Z_2 have been used with two entirely different meanings (as described in this letter) which cannot but lead to confusion. I advocate the adoption of the simple, logical, and easily remembered double-subscript notation employed in the following equations:

$$\begin{aligned} V_0 &= Z_{00}I_0 + Z_{01}I_1 + Z_{02}I_2 \\ V_1 &= Z_{10}I_0 + Z_{11}I_1 + Z_{12}I_2 \\ V_2 &= Z_{20}I_0 + Z_{21}I_1 + Z_{22}I_2 \end{aligned} \quad (1)$$

where V = voltage drops across any branch of a three-phase circuit, I = currents in the branch, and Z = impedances of the branch; subscripts 0, 1, 2 denote zero, positive, and negative phase sequence.

The analogous equations in phase quantities are as follows:

$$\begin{aligned} V_a &= Z_{aa}I_a + Z_{ab}I_b + Z_{ac}I_c \\ V_b &= Z_{ba}I_a + Z_{bb}I_b + Z_{bc}I_c \\ V_c &= Z_{ca}I_a + Z_{cb}I_b + Z_{cc}I_c \end{aligned} \quad (2)$$

where subscripts a, b, c denote the phases.

In both sets of equations the symbol Z for impedance has two subscripts, one referring to voltage and the other to current. The two subscripts of self-impedances are alike; those of mutual impedances are unlike. The order of the subscripts of a mutual impedance is significant, because the mutual impedance between phases or between sequences may be nonreciprocal, that is, it may have unequal values in the two directions. The order of subscripts is easy to remember, because the first subscript of impedance is like that of the voltage, which is written ahead of the impedance symbol; and the second subscript is like that of the current, which is written after the impedance symbol.

The meaning of the impedance symbols is apparent from the equations. For example, Z_{ab} is the ratio of the voltage across phase a to the current in phase b when there is no current in phases a and c; Z_{ba} is the ratio of the voltage across phase b to the current in phase a when there is no current in phases b and c. Impedances Z_{ab} and Z_{ba} are unequal if, for example, a and b are the stator windings of an induction machine having closed moving rotor circuits. Z_{12} is the ratio of positive-sequence voltage to the negative-sequence current when there is no positive- nor zero-sequence current; and so forth.

Each symmetrical-component impedance in equations 1 is a function of the nine phase impedances of equations 2, as indicated by the following table:

		Z_{aa}	Z_{bb}	Z_{cc}	Z_{bc}	Z_{ca}	Z_{ab}	Z_{cb}	Z_{ac}	Z_{ba}	
Z_{00}		1	1	1	1	1	1	1	1	1	
Z_{01}		1	a^2	a	a	1	a^2	a^2	a	1	
Z_{02}		1	a	a^2	a^2	1	a	a	a^2	1	
Z_{10}	1	1	a	a^2	a	a^2	1	a^2	1	a	
Z_{11}		1	1	1	a^2	a^2	a^2	a	a	a	(3)
Z_{12}	3	1	a^2	a	1	a^2	a	1	a^2	a	
Z_{20}		1	a^2	a	a^2	a	1	a	1	a^2	
Z_{21}		1	a	a^2	1	a	a^2	1	a	a^2	
Z_{22}		1	1	1	a	a	a	a^2	a^2	a^2	

which is to be interpreted thus:

$$Z_{01} = \frac{1}{3}(Z_{aa} + a^2Z_{bb} + aZ_{cc} + aZ_{bc} + \ldots),$$

etc.

where $a = \underline{/120°}$

The method of symmetrical components does not present any advantage over the use of phase quantities unless equations 1 are simpler than equations 2. The increased simplicity might lie in having reciprocal mutual impedances in equations 1 for nonreciprocal impedances in equations 2, or in having the mutual impedances in equations 1 vanish when those in equations 2 do not.

The conditions for which the intersequence impendances are reciprocal, that is, for which

$$Z_{01} = Z_{10}, \qquad Z_{02} = Z_{20}, \qquad Z_{12} = Z_{21}$$

is readily shown to be that

$$Z_{bb} = Z_{cc}, \quad Z_{ca} = Z_{ab}, \quad Z_{ac} = Z_{ba} \quad (4)$$

These conditions may be termed "symmetry with respect to phase a."

The conditions for which the intersequence impedances vanish are that

$$Z_{aa} = Z_{bb} = Z_{cc}, \quad Z_{bc} = Z_{ca} = Z_{ab}, \text{ and } Z_{cb} = Z_{ac} = Z_{ba} \quad (5)$$

These conditions may be called "balanced impedances."

With balanced phase impedances in equations 2, the only impedances in equations 1 that are not zero are the self-impedances Z_{00}, Z_{11}, and Z_{22}. Under these conditions the simpler notation Z_0, Z_1, Z_2, which is widely used, seems appropriate.

Another interesting special case is that in which the mutual impedances between phases are zero and the phase self-impedances are unequal. In this case,

$$Z_{00} = Z_{11} = Z_{22} = \frac{1}{3}(Z_{aa} + Z_{bb} + Z_{cc})$$

$$Z_{02} = Z_{10} = Z_{21} = \frac{1}{3}(Z_{aa} + aZ_{bb} + a^2Z_{cc})$$

$$Z_{01} = Z_{12} = Z_{20} = \frac{1}{3}(Z_{aa} + a^2Z_{bb} + aZ_{cc})$$

There are in this case only three different values of impedance in equations 1, but each one appears there three times. These three values sometimes are designated Z_0, Z_1, Z_2; and the so-called "sequence rule" is used, by which the sequence of a ZI drop is given by the sum of the subscripts of Z and I, for example,

$V_2 = Z_2I_0 + Z_1I_1 + Z_0I_2$, etc.

The notation Z_0, Z_1, Z_2 with this significance is not recommended because of confusion with the more usual significance, Z_{00}, Z_{11}, Z_{22}, for balanced phase impedances. The subscripts in this notation are the difference between the two subscripts in the recommended double-subscript notation.

In conclusion, the double-subscript notation of equations 1 is recommended for universal use, except that Z_0, Z_1, Z_2 may be used with their common meaning, as being equivalent to Z_{00}, Z_{11}, and Z_{22}, respectively with the added implication that the intersequence mutual impedances are negligible. The conditions of the phase impedances for which the inter-sequence mutual impedances vanish, and for which they are reciprocal, have been stated in equations 5 and 4, respectively.

Very truly yours,

EDWARD W. KIMBARK (A'27, M'35)

(Professor of Electrical Engineering, Polytechnic Institute of Brooklyn, Brooklyn, N. Y.)

Engineers and Social Problems

To the Editor:

Doctor Jewett's discussion of "The Engineer and Trends in Economic Thought" is most interesting; especially his characterization of the claims that the revival of ancient fallacies are scientific experiments. It would be just as legitimate and logical to attempt to disprove the rule of three, under the pretense of scientific experimentation, as to attempt to justify some of the present day economic and even engineering delusions under the same pretense.

I do wish, however, that Doctor Jewett had been a little more specific and concrete in stating exactly what engineers can and should do to dispel the hallucinations which seem to affect, or afflict, so much economic thought and even accounting practice that classifies liabilities as assets.

It is true that engineers have a responsibility in these matters, but it is likewise true that they have been remiss in the assumption and performance of this duty. An outstanding example of remissness is the refusal even to permit consideration of the suggestion that the Institute membership be polled on the proposition to investigate what Doctor Vannevar Bush so aptly characterized as a "fool piece of work in any language." The important issue, therefore, is not the engineers' responsibilities in the abstract, but their assumption of these responsibilities in the concrete.

Doctor Jewett again calls attention to the relation of science to the economic well-being of the people, and in partial justification of the adverse criticisms of science he cites some moral delinquencies of the present age. If, as the critics assume, scientific discoveries and inventions cause a decay of moral fiber, the mechanistic concept of life is proved, and the amelioration of social maladjustments can be achieved only by a change in environment. I doubt, however, the validity of such a conclusion. The motor car is not the cause of crime. It is merely an agency that facilitates criminal activities. Criminals always have used, and always will use, every facility available. Although it is true that standards of right and wrong change, nevertheless it is also true that an act that was wrong in the horse-and-buggy days does not become right by a mere change in vehicles. Neither the agency nor the surroundings have anything to do with the morality of the deed.

In most of the discussions of the relative mentality and intellectual achievements of men of the present and of past ages, it is tacitly assumed that the outstanding few of ancient times were typical of all. That assumption is disclosed in the extract from an article by Sir Gilbert Murray cited by Doctor Jewett. The fact is, however, that Millet's "Man with the Hoe" is just as typical of the ancient Chaldeans as Sir Gilbert Murray's "stupid fat man driving fast in a beautiful motor car," is of the present day. Stupid men are not exclusively the product of any particular age.

That the Chaldean astronomer was a man of high intellectual power, no intelligent man will deny, but in contrast astronomers of the present day, such as Sir James Jeans, are no weaklings.

In a comparatively recent address Sir James completely answers Sir Gilbert's gloomy forebodings:

"Unhappily, no amount of planning can arrange a perfect balance. For as the wind bloweth where it listeth, so no one can control the direction in which science will advance; the investigator in pure science does not know himself whether his researches will result in a mere labor saving device or a new industry. He only knows that if all science were throttled down, neither would result; the community would become crystallized in its present state, with nothing to do but watch its population increase, and shiver as it waited for famine, pestilence, or war which must inevitably come to restore the balance between food and mouths, land and populations.

"Is it not better to press on in our efforts to secure more wealth and leisure and dignity of life for our own and future generations, even though we risk a glorious failure, rather than accept inglorious failure by perpetuating our present conditions, in which these advantages are the exception rather than the rule? Shall we not risk the fate of that over-ambitious scientist, Icarus, rather than resign ourselves, without effort, to the fate which has overtaken the bees and ants? Such are the questions I would put to those who maintain that science is harmful to the race."

The affirmation of Sir James that science like the wind "bloweth where it listeth" is also a most cogent answer to Doctor Jewett's assumption that "we have failed to take seriously enough the matter of foreseeing and providing for the more important social consequences of our material achievements."

The fundamental fallacy of social and economic planners is the assumption that some persons possess the necessary omniscience to "foresee and provide for the consequences of our material achievements"; in short, that economic and social planning is possible.

Nevertheless, there are times when one is almost persuaded to agree with the critics of scientists and inventors. For example, when a popular writer of social and economic subjects asserts: "It would be a jolly good thing to declare a moratorium on inventions for at least a decade, and treat all inventors as dangerous lunatics with proper care and supervision," one is inclined to agree; for if the typewriter, typesetting, and electrotyping processes had never been invented there would be very limited circulation of such stark-staring stultiloquy.

Again, when an economist says that "the problem of the modern age is to adjust itself to the new monster, the machine," one is inclined to say, "it would be a jolly good thing" if some one invented an "oxometer" that would automatically delete such nonsense. Even this letter would be shorter if it were run through such a device.

Another dominant fallacy is the mistaken notion that money is wealth. This fallacy permeates the thinking processes of even some outstanding scientists, one of whom in a commencement address said:

"The blind faith in causation is the main source of most of the heated discussions on economic questions. A prominent editorial writer of one of our leading newspapers was led recently to vigorous denunciation of the plowing under of the cotton crop because he believed 'that the destruction of wealth cannot produce wealth.' He refers to this as though it were some great natural law. But where has such a law been proved? It appears, of course, an absurdity to produce wealth by destroying it, but we live in an absurd world in which the population has the capacity and the ability to produce enough commodities to sustain a high standard of living, yet because of unemployment there does not exist the purchasing power to permit its realization. Surely there is no natural law which proves that the destruction of a certain fraction of our wheat supply could not raise the total value of the remaining wheat sufficiently to offset the loss involved."

The proof of the accuracy of the editor's affirmation is found in a mythical fable of the sale of three books for the price originally asked for nine by the sibyl of Cumae to Tarquinius Superbus. The emperor paid the price, but he got only three books after six were destroyed.

It is entirely proper and fitting that men of the scientific standing of Doctor Jewett contribute their thoughts to the eradication of absurdities and pernicious practices. It must not be forgotten, however, that man in the future as in the past will use the discoveries of science as he sees fit without regard to the advice and foresight of the engineer. The greatest contribution that engineers and scientists can make to society is to maintain their intellectual and moral integrities, which is the great present-day disederatum. This in itself will do much "to offset the superficial assumptions engendered by outward appearances," and "will impel men and women to seek advice from those who have it and to ponder this advice before acting." But before this consummation can be realized, the engineer must give his advice unsought.

Very truly yours,

C. M. Jansky (A'06, F'32)

(Professor of Electrical Engineering, University of Wisconsin, Madison)

Sharp Cutoff in Vacuum Tubes

To the Editor:

In a recent paper[1] the theoretical expression for the current of a high-vacuum diode is given as

$$I = I_s \exp\left(-eV/kT\right) \tag{1}$$

for low anode current and negative anode voltage, where I is the anode current, V the negative anode voltage, I_s the saturation current, T the absolute temperature of the emitter, e the charge of an electron, and k Boltzmann's constant. This equation was taken from a book by A. Hund.[2]

The expression for the diode current with a negative anode voltage for concentric cylindrical electrodes, a common commercial arrangement, was derived by Schottky[3] and given as

$$I = I_s \frac{2}{\sqrt{\pi}}\left\{ \sqrt{\frac{eV}{kT}} \exp\left(\frac{eV}{-kT}\right) + \int_{\sqrt{\frac{eV}{kT}}}^{\infty} \exp\left(-x^2\right)dx \right\} \tag{2}$$

It was pointed out by Schottky, and more completely by Davisson,[4] that this equation fails for $V = 0$ (since the current would then be the saturation current which is obtained only with relatively high anode voltages); fails for values of V which permit a space charge potential minimum between anode and cathode; and may fail even for values of V which do not permit a voltage minimum. It was shown by Germer[5] that the Schottky equation holds at large negative values of anode voltages.

The assumption made in using equation 1 was either that the electrodes were infinite parallel planes,[6] or that equation 2 reduces to the form of equation 1 for large values of V. The latter would obtain only if the second (probability) term is small and

$$\frac{2}{\sqrt{\pi}}\sqrt{\frac{Ve}{kT}} \approx 1$$

Both of these conditions cannot simultaneously exist, for the probability term is comparatively small only at very high anode voltages, and the second condition requires $V = 0.0678$ volts for $T = 1{,}000$ degrees Kelvin.

It is interesting to note, however, that an empirical equation of the form

$$I = A \exp\left(-BV\right) \tag{3}$$

where A and B are constants, holds over a limited range of negative anode voltage. Figure 1 shows curves of anode current plotted against voltage obtained from data on commercial tubes. It may be seen that equation 3 holds approximately for the type 5T4 which has a filamentary cathode, the type 59 tube which has two heater cathodes with unipotential surfaces and several

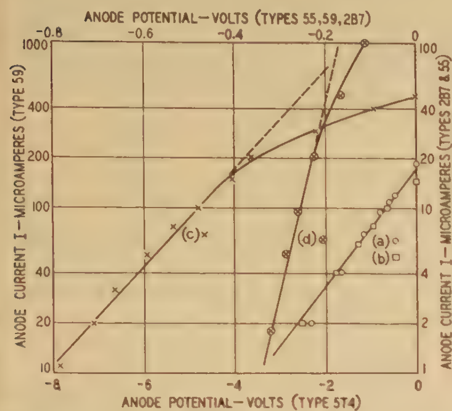


Figure 1. Curves of anode current versus negative anode voltage for commercial tubes

(*a*) Type 55 tube, diode section only; heater type

(*b*) Type 2B7 tube, diode section only; heater type

(*c*) Type 59 tube, pentode with grids and plate interconnected; heater type

(*d*) Type 5T4 tube, rectifier filamentary type with center tap of transformer used as cathode

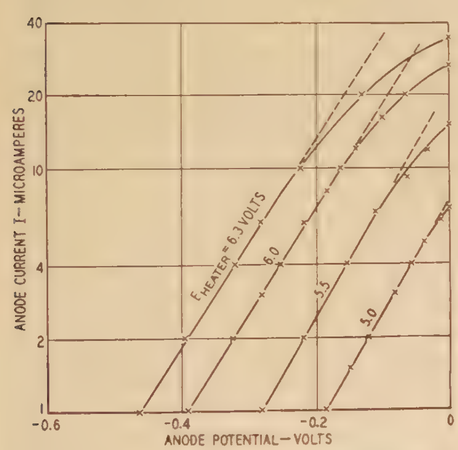


Figure 2. Curves of anode current versus negative anode voltage of 1-V tube for different heater voltages

grids, and for the types 2B7 and 55, which were used as diodes.

In figure 2 are plotted curves of anode current against voltage of a 1-V tube for various heater voltages. Equation 1 would predict lines of strikingly different slopes and would not apply to a cylindrical unipotential cathode tube like the 1-V. The curves are similar to those obtained by Germer, in his check of Schottky's equation.

It should be pointed out that the deductions in the paper by Aiken and Birdsall[1] are not affected by these comments, for, as seen from their equation 4, the term I_s is absorbed in a constant G which is adjustable by means of grid-voltage change.

Yours truly,

G. H. Fett (A'32)

(Department of Electrical Engineering, University of Illinois, Urbana)

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1. Sharp Cutoff in Vacuum Tubes, With Applications to the Slideback Voltmeter, C. B. Aiken and L. C. Birdsall. AIEE Transactions, volume 57, 1938 (April section) pages 171–6.

2. Phenomena in High-Frequency Systems, A. Hund, (a book). McGraw-Hill Book Company, page 7.

3. W. Schottky, *Annalen der Physik*, volume 44, 1914, page 1011.

4. C. Davisson, *Physical Review*, volume 25, 1925, page 808.

5. L. H. Germer, *Physical Review*, volume 25, 1925, page 795.

6. I. Langmuir, *Physical Review*, volume 21, 1923, page 419.

Personal Items

A. E. Kennelly (A'88, F'13, HM'33, Edison Medalist '33, past-president) has been elected honorary president of the International Electrotechnical Commission. Doctor Kennelly, who is professor emeritus of electrical engineering at Harvard University and Massachusetts Institute of Technology, was born near Bombay, India, December 17, 1861, and received his early education in private schools in Europe. He

A. E. KENNELLY

was awarded the honorary degree of doctor of science by the University of Pittsburgh in 1895, and by the University of Toulouse, France, in 1922, and received the honorary degree of master of arts from Harvard University in 1906. In 1875 he became assistant secretary of the Institution of Electrical Engineers (Great Britain). After holding various other positions he came to the United States in 1887, and was engaged as principal electrical assistant to Thomas A. Edison until 1894. In that year he became associated with Edwin J. Houston in the firm of Houston and Kennelly. Doctor Kennelly was appointed professor of electrical engineering at Harvard University in 1902, and continued in that position until he retired from active service in 1930. From 1913 until 1924 he was professor of electrical engineering at Massachusetts Institute of Technology, and for some years was director of electrical engineering research and chairman of the faculty of that institution. Doctor Kennelly has been honored by many scientific societies for his achievements. He served as a United States delegate to the international electrical congresses in Paris (1900) and St. Louis (1904) and the international radio conferences in Paris (1921) and Washington (1927). He is also honorary president of the United States National Committee of the International Electrotechnical Commission.

D. C. Jackson (A'87, F'12, past-president) has been appointed chairman of the Institute's committee on code of principles of professional conduct. Born at Kennett Square, Pa., Doctor Jackson received the degrees of bachelor of science and civil engineer from Pennsylvania State College, subsequently pursuing postgraduate study in electrical engineering at Cornell University for two years. He was awarded the honor-

D. C. JACKSON

ary degree of doctor of science by Columbia University. From 1887 until 1889 he was vice-president and engineer for the Western Engineering Company, Lincoln, Nebr. In the latter year he became assistant chief engineer with the Sprague Electric Railway and Motor Company, New York, N. Y., and in the following year became chief engineer for the Edison General Electric Company. In 1891 he formed a consulting engineering firm with W. B. Jackson and became professor of electrical engineering at the University of Wisconsin. In 1907 he became professor and head of the department of electrical engineering at Massachusetts Institute of Technology. Doctor Jackson formed a partnership with E. L. Moreland (A'11, F'21) in 1919 and was senior partner in the firm until 1930. In 1935 he retired

from active service at Massachusetts Institute of Technology and became professor emeritus of electrical engineering. Doctor Jackson was a vice-president of the Institute from 1897 until 1899 and was president during 1910–11. He has been a member of the committee on code of principles of professional conduct since 1936, and at various times has been member or chairman of many of the Institute's other committees. At present Doctor Jackson is a member of the committee on legislation affecting the engineering profession and the committee on standards.

R. W. Sorensen (A'07, F'13, director, past vice-president) has been appointed chairman of the Institute's committee on student branches for the year 1938–39. At present professor and head of the department of electrical engineering at California Institute of Technology, Pasadena, Calif., Doctor Sorensen was born at Alta Vista, Kans., April 25, 1882, and received the degrees of bachelor of science in electrical engineering (1905) and electrical engineer (1928) from the University of Colorado. The same school awarded him the honorary degree of doctor of science recently. He was employed by the General Electric Company at Schenectady, N. Y., and Pittsfield, Mass., from 1905 until 1910, when he was appointed associate professor of electrical engineering at Throop Polytechnic Institute, which later became California Institute of Technology. He was appointed professor during the following year. From 1933 until 1935 Doctor Sorensen was a vice-president of the Institute. At various times he has served as member or chairman of many of the Institute's technical and general committees, and currently is a member of the Edison Medal committee and the committee on economic status of the engineer.

K. B. McEachron (A'14, F'37, director) has been appointed chairman of the Institute's committee on protective devices for the year 1938–39. Doctor McEachron is director of high-voltage research at the Pittsfield (Mass.) works of the General Electric Company. He was born at Hoosick Falls, N. Y., November 17, 1889, and was graduated from the electrical-engineering course at Ohio Northern University in 1913. Recently he received the honorary degree of doctor of engineering from the same institution. Following his graduation in 1913 he was employed as a test engineer for the General Electric Company at Pittsfield, and during the next four years was an instructor in electrical engineering at Ohio Northern. From 1918 until 1922 he was a member of the staff of Purdue University, acting as instructor in electrical engineering and as research associate in the engineering experiment station. He received the degree of master of science in electrical engineering there in 1920. In 1922 Doctor McEachron returned to the General Electric Company at Pittsfield, and in 1933 was appointed to his present position. Currently a director of the Institute, Doctor McEachron has been a member of the committee on protective devices since 1933, and is a member of the committee on basic sciences also.

P. O. Crawford (A'09, M'25) has resigned as president of American Utilities Service Corporation, Savannah, Ill., to become operating vice-president of Central Service Corporation, Chicago, Ill. A native (1885) of Malvern, Ohio, Mr. Crawford attended The Ohio State University, and was graduated from Stanford University with the degree of bachelor of arts in electrical engineering in 1908. Following his graduation he became a construction engineer for the Northern California Power Company and remained there until 1912. In that year he became assistant chief engineer on the design and construction of a hydroelectric system in Kabul, Afghanistan. In 1915 Mr. Crawford returned to Stanford University to pursue research in high-voltage engineering and one year later he became associated with the California-Oregon Power Company, eventually becoming chief engineer (1920) and vice-president and chief engineer (1923). From 1929 until 1924 he was successively president, receiver, and trustee of the Federal Public Service Corporation, and upon reorganization of that corporation in 1934 he became president of American Utilities Service Corporation, the new company.

L. W. W. Morrow (A'13, F'25, past director) has been appointed chairman of the Institute's Edison Medal committee for the year 1938–39. Mr. Morrow is a native (1888) of Hammond, W. Va., and was graduated from Marshall College in 1907 and Cornell University in 1911. During the scholastic year following his graduation in 1911 he served as an instructor at Cornell University, and in 1913 was appointed assistant professor of electrical engineering at the University of Oklahoma. During the year 1917–18 he was professor of electrical engineering and director of the school of electrical engineering, before becoming assistant director of the United States Signal Corps school at Yale University. He served concurrently as an assistant professor of electrical engineering on the faculty at Yale, and following the World War was retained in that position. In 1922 Mr. Morrow became associate editor of *Electrical World;* in 1929 he became editor of that publication, but resigned in 1936 to become manager of the fiber products division of the Corning Glass Works, Corning, N. Y. He was a director of the Institute from 1933 until 1937. Mr. Morrow has been active in the committee work and other affairs of the Institute, and is at present chairman of the committee on constitution and by-laws and a member of the technical program committee. He is Institute representative on the Engineers' Council for Professional Development, and is a director and past vice-president of the Thomas Alva Edison Foundation.

H. L. Hazen (A'26) has been appointed professor and head of the department of electrical engineering of Massachusetts Institute of Technology, Cambridge. Doctor Hazen was born August 1, 1901 at Philo, Ill., and received the degrees of bachelor of science in electrical engineering (1924), master of science in electrical engineering (1929), and doctor of science in electrical engineering (1932) at MIT. He joined the teaching staff of MIT in 1926 and was advanced to the rank of associate professor in 1936. Aside from his academic work Doctor Hazen has had experience in the laboratories of the General Electric Company and the American Telephone and Telegraph Company. In 1934 he was awarded the Levy Gold Medal of the Franklin Institute for outstanding technical papers on the theory and design of servo-mechanisms. During the same year Doctor Hazen served as an exchange professor at The Ohio State University.

R. E. Hellmund (A'05, F'13, Lamme Medalist '29) has been appointed chairman of the Institute's committee on standards for the year 1938–39. Mr. Hellmund, who is chief engineer of the Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa., was born at Gotha, Germany, in 1879. Attended the Ilmenau Technical College, from which he was graduated with the de-

K. B. McEACHRON

L. W. W. MORROW

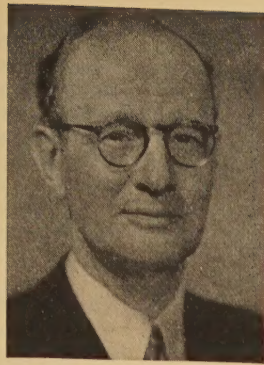
R. E. HELLMUND

Bachrach

R. W. SORENSEN

P. O. CRAWFORD

VANNEVAR BUSH



O. B. BLACKWELL

F. M. FARMER

gree of electrical engineer in 1898. After being engaged in electrical development work for three years, he attended the University of Charlottenburg, Berlin, as a graduate student. In 1903 he came to the United States and held several positions, including a brief affiliation with William Stanley at Great Barrington, Mass., until he was employed by the Western Electric Company, Hawthorne, Ill., in 1905. Since 1907 he has been associated with the Westinghouse Electric and Manufacturing Company, and has been chief engineer of the company since 1933. Mr. Hellmund has been a member of the Institute's standards committee since 1930, and is an alternate member of the electrical standards committee of the American Standards Association.

O. B. Blackwell (A'08, F'17) has been appointed chairman of the Institute's headquarters committee for the years 1938–39. Mr. Blackwell was born at Bourne, Mass., August 21, 1884. Upon receiving the degree of bachelor of science from Massachusetts Institute of Technology in 1906, he immediately entered the engineering department of the American Telephone and Telegraph Company. In 1914 he became transmission and protection engineer, and with the formation of the department of development and research in 1919 he became transmission development engineer. When that department was consolidated with the Bell Telephone Laboratories in 1934 Mr. Blackwell was appointed director of transmission development. In 1935 he was made manager of staff departments and in 1937 became vice-president of the laboratories. From 1936 until 1938 Mr. Blackwell was a vice-president of the Institute representing the AIEE New York City District, and has been a member of several committees. He has participated in the activities of the Edison Electric Institute and the American Standards Association.

F. M. Farmer (A'02, F'13) has been appointed chairman of the Institute's committee on planning and co-ordination for the year 1938–39. Mr. Farmer was born at Ilion, N. Y., in 1877, and was graduated from Cornell University in 1899. In 1903, after spending a year in a test department of the General Electric Company and $2^1/_2$ years in the inspection division of the United States Navy at the Brooklyn (N. Y.) Navy Yard, he joined the staff of the Electrical Testing Laboratories, Inc., New York, N. Y., then known as the Lamp Testing Bureau. At present he is vice-president and chief engineer of the Electrical Testing Laboratories. Mr. Farmer is a director of the Institute and a member of the technical program committee, the executive committee, and of the committees on standards, finance, and transfers. He is the Institute's representative on the Engineering Foundation board and the Engineering Societies monographs committee, and is a member of the board of trustees of United Engineering Trustees, Inc. Mr. Farmer has been active in various phases of the work of the American Standards Association as chairman or member of several of its sectional committees.

H. M. Sharp (M'34) has been elected general secretary of the Illuminating Engineering Society. Mr. Sharp, who is vice-president of the Buffalo, Niagara, and Eastern Power Corporation, Buffalo, N. Y., was born at Buffalo in 1892, and received the degree of mechanical engineer at Cornell University in 1915. Following his graduation he served briefly as an instructor in mechanical engineering at Cornell University, as an assistant engineer with the Bethlehem Steel Company, Lackawanna, N. Y., and with the United States Army, before becoming efficiency engineer at the Huntley station of the Buffalo General Electric Company in 1919. In 1926 he accepted a similar position with the Indiana Electric Corporation, Terre Haute, Ind., but returned to the Buffalo General Electric Company in 1928 as assistant chief engineer of Huntley station. On completion of the second Huntley station Mr. Sharp was made assistant superintendent of both stations in 1930; in 1931 he became superintendent, which position he held until he was elected to his present position in 1937.

V. P. Hessler (A'29, M'36) has been appointed chairman of the electrical engineering department of the University of Kansas, Lawrence. Doctor Hessler was born September 6, 1903, at Durant, Ia., and received the degree of bachelor of science in electrical engineering from Oregon State College in 1926. In the following year he enrolled in the graduate school at Iowa State College and received there the degrees of master of science in electrical engineering (1927) and doctor of philosophy in electrical engineering (1934). In concurrence with his graduate studies at Iowa State he served as an instructor in electrical engineering. In 1936 Doctor Hessler was promoted to the rank of assistant professor of electrical engineering. He is the author of several papers on carbon brushes for electrical machinery.

F. W. Hurlbert (A'04) has retired from active service in the International General Electric Company, New York, N. Y. Mr. Hurlbert was born June 3, 1870 at Aurora, Ind., and was graduated from Rose Polytechnic Institute in 1891. After serving with various companies he was employed in the railway engineering department of the General Electric Company at Schenectady, N. Y., where he remained five years. In 1901 Mr. Hurlbert was transferred to Buffalo, N. Y., to represent the General Electric Company at the Pan American Exposition in that year. In the following year he entered the foreign department of the company and later was transferred to the New York offices of the International General Electric Company.

G. T. Shoemaker (M'20) recently was appointed general manager of the United Light and Power Company, Kansas City, Mo. A native (1886) of Geneva, Ind., Mr. Shoemaker was graduated from Purdue University in 1910 with the degree of bachelor of science in electrical engineering; in 1916 he received the degree of electrical engineer from that school. Mr. Shoemaker has been associated with the United Light and Power Company and its subsidiaries for more than 25 years, and will serve in a similar capacity with the United Light and Railways Company, Continental Gas and Electric Corporation, and American Light and Traction Company. He will serve the United Light and Power Service Company as president.

Vannevar Bush (A'15, F'24, Lamme Medalist '35) has been appointed chairman of the Institute's Lamme Medal committee for the years 1938–39. Doctor Bush is vice-president of the Massachusetts Institute of Technology and president of the Carnegie Institution of Washington. In announcing his election to the latter position, a biographical sketch of Doctor Bush appeared on page 319 of the July 1938 issue of ELECTRICAL ENGINEERING. For the current year he is the Institute's representative on the council of the American Association for the Advancement of Science and on the National Research Council's division of engineering and industrial research.

F. B. Powers (M'37) has become engineering manager of the combined generator and transportation divisions of the Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa. A native (1904) of Chicago, Ill., Mr. Powers has been associated with the Westinghouse Company continuously since his graduation in electrical engineering from the University of Illinois in 1926. In 1927 he was transferred to the railway motor engineering department, in 1935 was promoted to section engineer of d-c traction motors, and in the following year became manager of engineering of the transportation department.

A. H. Lovell (A'12, M'13, vice-president) has been appointed chairman of the Institute's committee on economic status of the engineer. He is assistant dean and secretary of the University of Michigan, Ann Arbor. A

A. H. LOVELL

biographical sketch of Dean Lovell appeared on page 140 of the March 1938 issue of ELECTRICAL ENGINEERING, in announcement of his nomination as vice-president of the AIEE Great Lakes District.

R. W. Krass (A'06, M'12) recently was appointed central station manager of the eastern district of the Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa., with offices at New York, N. Y. Since 1935 Mr. Krass has been manager of the marine division of the company's eastern district, and will continue to hold that position. He was graduated from Cornell University with the degree of mechanical engineer in 1906, in the same year joining the Westinghouse, Church, Kerr Company as an electrical engineer. In 1910 he became affiliated with the New York Edison Company as cable engineer, and in 1918 left that company as assistant chief engineer.

F. D. Newbury (A'07, F'21) has been appointed manager of the new products division of the Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa. Born in Brooklyn, N. Y. and graduated from Cornell University with degree of mechanical engineer in 1901, Mr. Newbury has been associated with the Westinghouse Company continuously in several positions. Besides his regular engineering work Mr. Newbury edited *The Electric Journal* when it was established in 1904. In 1935 he became assistant to the vice-president and later was appointed economist with the company, a position he still retains. He was a director of the Institute from 1918 until 1922.

K. W. Mowry (A'31) now is electrical distribution engineer for the Houston Lighting and Power Company, Houston, Texas. Mr. Mowry has been operating departmental foreman for the U. S. Phosphoric Products Corporation, Tampa, Fla.

L. H. Allcorn, Jr. (A'38) now is maintenance engineer for Briarcliff Lodge, Briarcliff Manor, N. Y. Formerly Mr. Allcorn was engineer for Hazelett Metals, Inc., Greenwich, Conn.

W. A. Laning, Jr. (A'29) has been appointed assistant professor of electrical engineering at the University of Maryland, College Park. Doctor Laning was born at New Kensington, Pa. in 1906 and was graduated from Bucknell University with the degree of bachelor of science in electrical engineering. Later he received the degrees of master of science in electrical engineering and doctor of philosophy from the University of Illinois. Until his recent appointment he was a member of the faculty of Gettysburg College.

F. H. Doremus (A'24, M'32) has become district manager of the industrial department, General Electric Company, Denver, Colo. A native (1901) of Neligh, Nebr., and a graduate of the University of Nebraska in the class of 1922, Mr. Doremus has been associated with the General Electric Company continuously since his graduation, and has been in the Denver offices of that company since 1925.

A. G. Gower, Jr. (M'38) has become associate electrical engineer for the bureau of agricultural engineering, division of plans and service, United States Department of Agriculture, Washington, D. C. Formerly Mr. Gower was employed by the Westinghouse Electric and Manufacturing Company as a central station engineer at Boston, Mass.

F. T. Hague (A'14) has been transferred to the South Philadelphia (Pa.) works of the General Electric Company as manager of engineering of the steam division. Formerly Mr. Hague was manager of the d-c eingneering department at the East Pittsburgh (Pa.) works of the company.

W. P. Graham (A'02, F'23) has been awarded the honorary degree of doctor of laws by Colgate University. He is chancellor of Syracuse University, Syracuse, N. Y., and has been affiliated with that institution for 40 years.

W. O. Ray (A'35) has been advanced from instructor to assistant professor in electrical engineering at the Michigan College of Mining and Technology, Houghton.

Obituary

Dan E. Carpenter (M'15) dean of the faculty of the International Correspondence Schools, Scranton, Pa., died September 7, 1938. Mr. Carpenter was born October 21, 1866, at Starruca, Pa., and was graduated from Pennsylvania State College with a degree in electrical engineering in 1899. Following his graduation he became electrician in charge of equipment at the Pennsylvania State Reformatory, Huntingdon, but after two years was appointed assistant to the engineer of the Sprague Electric Company at Bloomfield, N. J. He first became associated with the International Textbook Company in 1905 as a technical writer. Two years later he was employed in the publication department of the Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa., where he remained until 1913. In that year he returned to the employ of the International Textbook Company as assistant manager of the textbook department, and three years later was appointed dean of the faculty of the International Correspondence Schools. In 1924 Mr. Carpenter assumed the additional responsibilities of vice-president of the International Textbook Company.

Victor Frederiksen (A'32) electrical engineer for the National Electric Coil Company, Columbus, Ohio, died April 23, 1938. Mr. Frederiksen was born January 7, 1895, at Rödkärsbro, Denmark, and attended the Katedralskolen of Viborg (Denmark). In 1912 he came to the United States and received employment with the Norfolk and Western Railway Company, Roanoke, Va. Following brief affiliations with the Virginian Railway Company, the West Virginia Armature Company, and the American Armature Company, he became foreman of the coil manufacturing department of the Charleston Electrical Supply Company in 1921. Five years later Mr. Frederiksen became electrical engineer for the National Armature and Electric Works, Columbus, later holding a similar position with the National Electric Coil Company.

Edwin Ruthven Weeks (A'87, M'87, F'13) retired consulting electrical engineer, Kansas City, Mo., died August 17, 1938. Mr. Weeks was born December 25, 1855, at New York, N. Y., and received his formal education at the Phillips Exeter Academy. He founded the first commercial electric light company in Kansas City in 1881 and became its superintendent and manager in 1882. In 1900 he sold the Kansas City Electric Light Company and formed the consulting-engineering firm of Weeks, Kendall, and Newkirk. Mr. Weeks was an active participant in the early affairs of the former National Electric Light Association, of which he was president during 1889–90. Although Mr. Weeks was most generally known for his pioneering in the electric light and power industry, he was known nationally as a humanitarian.

William J. K. Sutherland(A'15) superintendent of the electric construction division of the Rochester Gas and Electric Corporation, Rochester, N. Y., died in March 1938, according to word just received at Institute headquarters. Mr. Sutherland was born April 6, 1875, in Scotland. In 1894 he was employed by the Rochester Electric Railway and Light Company. He remained with that company until 1921, eventually becoming construction and electrical foreman. Mr. Sutherland became superintendent of electrical construction for the Rochester Gas and Electric Corporation in 1921 and served continuously in that capacity.

Leo Brandenburger (A'37) manufacturers' representative, Salt Lake City, Utah, died February 11, 1938. Mr. Brandenburger was born November 5, 1880 at Linneus, Mo., and was graduated from the University of Missouri with the degree of bachelor of

science in electrical engineering in 1903. Immediately following his graduation he was employed by the Telluride Power Company at Provo, Utah, where he remained until 1912 in various positions. Fom 1912 until 1915 he was superintendent of power sales for the Utah Power and Light Company, Salt Lake City. In the latter year he became sales engineer for the Wagner Electric Corporation; in 1918 he was appointed branch manager, and his service in that position extended over a period of almost 20 years.

William George Nagel (A'03) president of the Zonolite Company, Detroit, Mich., died July 20, 1938. Mr. Nagel was born May 22, 1873 at Wapakoneta, Ohio, and was graduated from The Ohio State University with the degree of mechanical engineer in 1895. Following three years of electrical construction work he became president and manager of the W. G. Nagel Electric Company, Toledo, Ohio. He continued in that business until 1935, when he became president of the Zonolite Company.

Herbert Charnock Jennison (A'05) technical manager of the American Brass Company, Waterbury, Conn., died June 12, 1938. Mr. Jennison's early experience was gained in the laboratories of the Coe Brass Manufacturing Company, Ansonia, Conn., and he had been associated with the American Brass Company since 1913.

Charles Anthony Miller (A'21) secretary of the Okonite Company, Passaic, N. J., died August 23, 1938. Mr. Miller was born September 5, 1884, in New York, N. Y. He was employed by the Okonite Company in 1899 and spent all of his business life with that organization.

Membership

Recommended for Transfer

The board of examiners, at its meeting on September 15, 1938, recommended the following members for transfer to the grade of membership indicated. Any objection to these transfers should be filed at once with the national secretary.

To Grade of Fellow

Dow, James C., Glendale, Calif.
Way, S. B., president, The Milwaukee Electric Railway and Light Company, Milwaukee, Wis.

2 to Grade of Fellow

To Grade of Member

Best, I. W., chief electrician, El Paso Electric Company, El Paso, Texas.
Cozzens, B., research engineer, Los Angeles Bureau of Power and Light Company, Los Angeles, Calif.
Dortort, I. K., assistant engineer, Allis-Chalmers Manufacturing Company, Milwaukee, Wis.
Ennis, A. G., assistant professor of electrical engineering, George Washington University, Washington, D. C.
Fett, G. H., instructor, University of Illinois, Urbana.
Flint, T. R. C., engineer in charge of power department Toronto Hydroelectric System, Toronto, Ont., Canada.
Georgiev, A. M., engineer in charge of design and development of electrolytic condensers, General Motors Corporation, Dayton, Ohio.
McFarland, R., equipment engineer, Southwestern Bell Telephone Company, St. Louis, Mo.
Metzger, A. F., application engineer, General Electric Company, Boston, Mass.
Montgomery, G. D., division transmission engineer, American Telephone and Telegraph Company, Denver, Colo.
Robertson, L. M., transmission and station engineer, Public Service Company of Colorado, Denver.
Robertson, W. G., assistant valuation engineer, State Corporation Commission of Virginia, Richmond, Va.

12 to Grade of Member

Applications for Election

Applications have been received at headquarters from the following candidates for election to membership in the Institute. If the applicant has applied for direct admission to a grade higher than Associate, the grade follows immediately after the name. Any member objecting to the election of any of these candidates should so inform the national secretary before October 31, 1938, or December 31, 1938, if the applicant resides outside of the United States or Canada.

United States and Canada

Anderson, L. T., Lewis Institute, Chicago, Ill.
Ballou, H. P., Rural Electrification Administration, Paxton, Ill.
Blaize, L. J., Dallas Power and Light Company, Dallas, Texas.
Bradley, E., Southwestern Bell Telephone Company, Houston, Texas.
Brink, E. H., Standard Oil Company, Niles, Mich.
Cohen, R. L., Philadelphia Board of Education, Philadelphia, Pa.
Cozzens, R. I., Keystone Pipe Line Company, Philadelphia, Pa.
Davies, M. W. H., The Commonwealth Fund, New York, N. Y.
Everett, R. R., Electrical Engineers Equipment Company, Melrose Park, Ill.
Fraser, E. G., Canada Wire and Cable Company, Ltd., Toronto 2, Ont., Canada.
Gertzon, N., M. W. Kellogg Company, New York, N. Y.
Giobbi, J., Tennessee Valley Authority, Pickwick Dam, Tenn.
Hall, J. E., Jr., Louisiana Power and Light Company, Algiers, La.
Heemer, W. L., Southwestern Bell Telephone Company, Houston, Texas.
Holden, H., Jr., Southwestern Bell Telephone Company, Houston, Texas.
Jennings, J. E., Southwestern Bell Telephone Company, Houston, Texas.
Jolliff, E. N., City Signal Building, Forth Worth, Texas.
Keathley, T. L., Southwestern Bell Telephone Company, Houston, Texas.
McDermott, B., Southwestern Bell Telephone Company, Oklahoma City, Okla.
McNeill, H. E., Imperial Irrigation District, Imperial, Calif.
Melloh, A. W., University of Minnesota, Minneapolis.
Miner, R. W., New York Telephone Company, New York, N. Y.
Moore, H. G., General Electric Company, Erie, Pa.
Nelson, V. J., Washington Water Power Company, Wallace, Idaho.
Ohnell, E., Jr., Kerite Cable Company, New York, N. Y.
Parr, V. P., Southwestern Bell Telephone Company, Houston, Texas.
Redmann, A. J., 5736 Midway Park, Chicago, Ill.
Riley, G. H., Southwestern Bell Telephone Company, St. Louis, Mo.
Ross, R. V., Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa.
Schutz, T., Southwestern Bell Telephone Company, Houston, Texas.
Waldron, R. C., (Member) Okonite Company, Passaic, N. J.

Total, United States and Canada—31

Elsewhere

Cervino, C. A., International Business Machines Corporation, Caracas, Venezuela.
Gill, T., (Member) Rangoon Electric Tramway and Supply Company Ltd., Rangoon, Burma.
Inarritu, F., (Member) Comisión Federal de Electricidad, Mexico City, Mexico.
MacDonald, N. B., (Member) McColl Electric Works Pty., Ltd., Victoria, Australia.
Mackerras, A. P., Sydney County Council, Sydney, New South Wales, Australia.
Rao, S. P., electrical department, Bezwada Municipality, Bezwada, South India.
Richards, S. H. (Member) Electricity Commission, Savoy Court, Strand, W. C. 2, London, England.
Roast, C. A. (Member) Nigerian Electric Supply Corporation, Bukuru, Northern Nigeria, British West Africa.
Schaer, E., Compania Minera de Oruro, Oruro, Bolivia.
Trivedi, P. R., Junagadh State Electric Supply Works, Veraval, India.
Turco-Rivas, L., Ministry of Public Works, Caracas, Venezuela.

Total elsewhere—11

Addresses Wanted

A list of members whose mail has been returned by the postal authorities is given below, with the addresses as they now appear on the Institute record. Any member knowing of corrections to these addresses will kindly communicate them at once to the office of the secretary at 33 West 39th St., New York, N. Y.

Barrett, Earl J., Don Pedro Dam, La Grange, Calif.
Cervenka, Frank J., 5736 Midway Park, Chicago, Ill.
De Lay, R. E., 77 Prospect Ave., Long Beach, Calif.
Fetter, Charles H., Electrical Research Products, 250 W. 57th St., New York, N. Y.
Kapell, Sidney M., 3043 Emmons Ave., Brooklyn, N. Y.
Marshall, Myron B., Jr., 606 State St., Schenectady, N. Y.
Platterer, Alvin, 776 N. Cass St., Milwaukee, Wis.
Renking, H. L., 208 N. Broadway, St. Louis, Mo.
Robison, R. L., 941 E. Northlake Ave., Seattle, Wash.
Shimp, Robert P., 414 Hampton Ave., Wilkinsburg, Pa.
Skina, Fred A., 626 Ash St., Moscow, Idaho.
Thrush, George H., Jr., 595 Union Trust Bldg., Pittsburgh, Pa.
Whitney, T. G., Electrical Research Products, Inc., 250 W. 57th St., New York, N. Y.
Wilson, Alexander, 315 New Birks Bldg., Montreal, Que., Can.

14 Addresses Wanted

Engineering Literature

New Books in the Societies Library

Among the new books received at the Engineering Society Library, New York, recently are the following which have been selected because of their possible interest to the electrical engineer. Unless otherwise specified, books listed have been presented gratis by the publishers. The Institute assumes no responsibility for statements made in the following outlines, information for which is taken from the preface of the book in question.

ELECTRICAL ENGINEERING. By C. V. Christie. Fifth edition. New York and London, McGraw-Hill Book Company, 1938. 717 pages, diagrams, charts, tables, 9 by 6 inches, cloth, $5.00. This fifth edition of a standard textbook has incorporated additional details of a practical nature to make the book of more permanent value. New material includes the two-reaction method for analyzing the operation of synchronous machines; an outline of the theory of the three-winding transformer; additional information upon induction motors; and a chapter on symmetrical components. The book aims to present a logical development of the theory of electrical circuits and machinery which will give a background for advanced study in any special field.

ELEKTRISCHE ISOLIERSTOFFE. ("Sammlung Vieweg," Tagesfragen aus den Gebieten der Naturwissenschaften und der Technik, Heft 114). By P. Böning. Braunschweig, Ger., Friedr. Vieweg & Sohn, 1938. 134 pages, illustrated, 9 by 5 inches, paper, 8.80 rm. A discussion of the behavior of electric insulating materials on the basis of ionic adsorption at the inner boundary surface. Part I covers general colloidal and physical fundamentals. Part II describes investigations concerning space charge, distribution of potential, residual phenomena, dielectric losses, and ionic breakdown.

BUSINESS CORRESPONDENCE and OFFICE MANAGEMENT. By E. A. Duddy, L. E. Frailey, and R. V. Cradit. Chicago, American Technical Society, 1938. 234 pages, illustrated, 9 by 6 inches, cloth, $1.75. The business letter, its importance, analysis of problems, letter form, and the various kinds of letters constitute the first section of this book. The second is devoted to the modern scientific technique of office management, including organization principles, filing methods, business machines, and other miscellaneous office equipment.

ELEMENTARY PRACTICAL MECHANICS. By J. M. Jameson and C. W. Banks. Fourth edition. New York, John Wiley and Sons, 1938. 363 pages, illustrated, 9 by 6 inches, cloth, $2.75. Designed primarily for elementary technical and manual training schools, and as an introductory course in engineering colleges.

Pamphlet Copies of Papers Available

¶ Limited quantities of pamphlet copies of the technical papers listed, representing surplus stock remaining from recent AIEE conventions and District meetings, are still available.

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City

State

Papers Presented at North Eastern District Meeting, Lenox, Mass., May 18–20, 1938

No.	Authors	Titles of Papers (Some Shortened)
☐ 38-40	McEachron	*Multiple Lightning Strokes—II
☐ 38-41	Lennox & DeBlieux	*A Direct-Current Transformer
☐ 38-42	LaPierre & Mansfield	*Photoelectric Weft-Straightener Control
☐ 38-44	Sporn & Gross	*Protector-Tube Application and Performance on 132-Kv Lines—II
☐ 38-45	Brosnan	*System Planning and Operation for Voltage Control
☐ 38-46	Benner & Lunge	*Voltage-Regulating-Equipment Characteristics
☐ 38-47	Landis	*Voltage Regulation and Control of Rural Lines
☐ 38-48	Burrell & Appleton	*The Periodic Voltage Survey as a Basis for Distribution Design
☐ 38-49	Rogers	*Regenerative Tension Control for Paper Winders
☐ 38-50	Bendz	*Comparison of Methods of Stopping Squirrel-Cage Induction Motors
☐ 38-51	Von Sothen	*The Application of Capacitors in Industrial Plants
☐ 38-52	Vogel	*Corona Voltages of Typical Transformer Insulation

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No.	Authors	Titles of Papers
☐ 37-58	Smith & Weygandt	*Double Line-to-Neutral Short Circuit of an Alternator
☐ 37-866	Appleman	*The Cause and Elimination of Noise in Small Motors
☐ 38-53	Calvert	Amplitudes of the MMF Harmonics for Fractional Slot Windings
☐ 38-54	Porter	Positive-Grid Characteristics of Triodes
☐ 38-55	Bewley	Traveling Waves Initiated by Switching
☐ 38-56	Subcommittee Report	Line-Type Lightning-Arrester Performance Data
☐ 38-57	Fonda	The Fundamental Principles of Fluorescence
☐ 38-58	Whitehead	*Lightning Protection of 22-Kv Substations
☐ 38-59	Poritsky	Graphical Field-Plotting Methods in Engineering
☐ 38-60	Reagan	*A Self-Checking System of Supervisory Control
☐ 38-61	Race	*Tests on Oil-Impregnated Paper—III—Fluid Flow
☐ 38-62	Spurck & Strang	A New Multibreak Interrupter for Fast-Clearing Breakers
☐ 38-63	Champe & Von Voigtlander	System Analysis for Petersen Coil Application
☐ 38-64	Gulliksen	A Position Regulator for Paper Slitters
☐ 38-65	Prince & Williams	The Current-Limiting Power Fuse
☐ 38-66	Clem	Application of Capacitance Potential Devices
☐ 38-67	Curry	The Co-ordination of Mathematics and Physics
☐ 38-68	Malti	Mathematics and Physics in Engineering
☐ 38-69	Stanley	An Analysis of the Induction Machine
☐ 38-70	Brownlee & Dent	Remote Control of Network Protectors
☐ 38-71	Bellaschi & Aggers	Radio-Influence Characteristics of Electrical Apparatus
☐ 38-72	Cole	Flashover Characteristics of Transformer Condenser Bushings
☐ 38-73	Terman	Analysis and Design of Harmonic Generators
☐ 38-74	Schelkunoff	Transmission Theory of Spherical Waves
☐ 38-75	Lyman & North	*Application of Large Phase-Shifting Transformer
☐ 38-76	Morgan	Co-ordination of Mathematics and Physics With EE Subjects
☐ 38-77	Inglis	*Transmission Features of the New Telephone Sets
☐ 38-78	Wahlquist & Taylor	Noise Co-ordination of Rural Power and Telephone Systems
☐ 38-81	Jones	*Instruments for the New Telephone Sets
☐ 38-82	Teare	A Course to Develop Facility in Mathematics and Physics
☐ 38-83	Bryant	Co-ordination of Physics With Electrical Engineering
☐ 38-84	Sporn & St. Clair	Tests and Performance of a High-Speed Multibreak Breaker
☐ 38-85	Dickinson	"De-ion" Air Circuit Breakers
☐ 38-86	Sandin	Enclosed Low-Voltage "De-ion" Breaker of High Capacity
☐ 38-87	Treanor	The Wound-Core Distribution Transformer
☐ 38-88	Sorensen	The Economic Status of the Engineer
☐ 38-90	Williams	*Combined Thyratron and Tachometer Control of Small Motors
☐ 38-91	Summers	A Static Constant-Current Circuit
☐ 38-92	Hazeltine	Basic Equations for Electric and Sound Radiation
☐ 38-93	Inman & Thayer	Low-Voltage Fluorescent Lamps
☐ 38-94	McDermott	High-Voltage Gaseous and Fluorescent Tubes
☐ 38-95	Pakala	A Memory Attachment for Oscilloscopes
☐ 38-96	Kouwenhoven & Lotz	Absolute Power Factor of Air Capacitors
☐ 38-97	Rusher & Mershon	The Electric Strain Gauge
☐ 38-98	Concordia, Crary & Lyons	Stability Characteristics of Turbine Generators

Papers Presented at Pacific Coast Convention, Portland, Ore., August 9–12, 1938

No.	Authors	Titles of Papers
☐ 38-43	Lightning Arrester Subcom.	Testing and Application of Lightning Arresters
☐ 38-99	Monroe	Electrification of the San Francisco-Oakland Bay Bridge Railway
☐ 38-100	Whelchel	Trends in Electrical Equipment in Hydraulic Power Plants
☐ 38-101	McMillan	Polarity Limits of the Sphere Gap
☐ 38-102	Smith	Use of Bismuth Bridge Magnetic Fluxmeter for A-C Fields
☐ 38-103	Shuck	A Variable-Register-Ratio Watt-Hour Meter
☐ 38-104	Thomson	Similitude of Critical Conditions in Ferroresonant Circuits
☐ 38-105	Morris	Application of Copper-Oxide Rectifiers
☐ 38-106	Wagner	Self-Excitation of Induction Motors
☐ 38-107	Ager	Determination of Induction-Motor Performance
☐ 38-108	Dalziel	Static Power Limits of Synchronous Machines
☐ 38-109	Peterson	General Operation of Transmission Line
☐ 38-110	Cozzens & Peterson	Corona Experience on Transmission Line
☐ 38-111	Cozzens	Insulation and Lightning Protection
☐ 38-112	Lauglin	Carrier-Current Equipment
☐ 38-113	Draper	Transmission-Line Relay Protection
☐ 38-114	Skellett	Narrow-Band Transmission System for Animated Line Images
☐ 38-115	Norwine	Controlling Amplitude Characteristics of Telephone Signals
☐ 38-116	Gaylord	The Pumping System of the Colorado River Aqueduct
☐ 38-117	Skilling	The Electrical Strength of Air at High Pressure
☐ 38-118	Pierce and Hamilton	Phase-Angle Control of System Interconnections
☐ 38-119	Lyon	The Electrostatic Unbalance of Transmission Lines

* These papers have been published in the TRANSACTIONS section of ELECTRICAL ENGINEERING.